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FUNCTION OF TECHNOLOGICAL EDUCATION

THE collection of essays constituting the preliminary survey of the nature and efficacy of technical education, which the United Nations Educational, Scientific and Cultural Organization has published under the title "Education in a Technological Society"*, emphasizes the need for social foresight in estimating technological needs and in providing suitable education. Much more is intended by this than forecasting future requirements for particular classes of technological or technical experts and attempting to adjust supply to demand. It envisages also the question of flexibility so as to ease transfer from one occupation to another, and the problems which are presented by changing age-structure and elderly workers.

This need for social insight has been well indicated by a number of recent management studies in Great Britain; and it is further stressed in an international study of the "Sense of Belonging in Industry" made by two of the authors of one of these studies, whose services were made available by the British Institute of Management. This study also has been published by the United Nations Educational, Scientific and Cultural Organization under the title "The Community Factor in Modern Technology"†. Following a well-documented review of the discords of industrial society, it presents, first, twelve European studies of organizations which helped to maintain a community and of organizations which fostered the creation of a sense of community where none had existed, and, secondly, two case studies of the process of maintaining and fostering communities. The latter utilize material already reported in Great Britain; but the conclusions drawn regarding satisfactions in industry and on the need and methods for study outlined in the following two chapters are not based simply on this evidence.

The main purpose of the book is to demonstrate the reason for believing that industry can play a major part in maintaining existing, and in fostering the growth of new, communities. This belief has been confirmed whenever the discords of industrial society have been strident enough to demand analysis, and Mr. Scott and Mr. Lynton consider it would be reasonable to expect that attention to the community factor in industry would result in many individuals finding the security and stability which they now lack. This change should greatly reduce neurotic and anti-social behaviour: much psychosomatic illness is traceable to industrial situations. Responsibility can also reasonably be expected to be diffused through an organization, community, region or nation, leading to more equal sharing of burdens and satisfactions. This might revise the growing tendency of society to consist of a few at the centre with too

* Education in a Technological Society: a Preliminary International Survey of the Nature and Efficacy of Technical Education. (Tensions and Technology Series.) Pp. 76. 200 francs; 4s.; 75 cents.

† The Community Factor in Modern Technology: an International Study of the 'Sense of Belonging' in Industry. By Jerome F. Scott and R. P. Lynton. (Tensions and Technology Series.) Pp. 170. 300 francs; 6s.; 1 dollar.
(Paris: Unesco; London: H.M. Stationery Office, 1952.)

much to do, and many at the periphery with no community responsibilities.

In drawing this conclusion, the report is stating in other words and in a fresh context the importance of genuine local self-government as the basis of a democratic society, and the whole trend of the conclusions of Mr. Scott and Mr. Lynton points to the vital necessity for reform at that level as much as for developments in industry. They suggest that a balance and integration of social classes and economic interests may be expected to replace the cycle of domination of society by successive groups, and that the reconciliation of interests would thus be possible without unmanageable conflicts. It requires an integrated community to enable the various interests to co-operate around the fundamental principle that wealth is increased only through increased productivity, not through strife; and the report suggests that our capacity to communicate with others may be expected to develop greatly, rendering it easier to become adapted to changes of all sorts, since we should have roots in communities, and daily practice of effective communication and adaptation.

In this sense, responsible membership of a real community is training for living in the world community; and as status systems attuned to the needs of the times develop, we may expect really representative institutions to throw up regional and national leaders. Community could thus co-operate with community, region with region, and national policies could be evolved and continuously adapted. Moreover, the growth of many spontaneous and autonomous arrangements between effective social institutions and between communities may be expected to replace some national policies which have been born of the failures of institutions and communities and now hinder their growth.

Mr. Scott and Mr. Lynton in this report provide a reasonable basis for such expectations; although, in their summing up, they give insufficient weight to the obstacles and prejudices which such trends will have to overcome even within any one country. We may perhaps disregard for the present any effect they are likely to have on international co-operation; but in technological development and in both the planning and the content of technological and technical education, due weight must be given to the implications of such factors. They are highly relevant to discussions on modern industrial organization such as Political and Economic Planning has published in two recent broadsheets: No. 348, "New Thinking on Monopoly", and No. 350, "The Structure of Industry and the Technical Revolution".

The first of these broadsheets traces the development of thought on monopoly up to the present time, when it is seen as a problem of power, and, as such, a question for politicians rather than economists. The efficacy or otherwise of the means available for counteracting monopoly obviously can have powerful repercussions on the development of community ideas; but the second broadsheet is concerned essentially with the various technological and other factors affecting the growth of business firms. Efficiency, it is emphasized in the Unesco report, is no longer seen almost as a function of size; on the contrary, even in industries most favourably disposed to mass production, there is a tendency, defended essentially in social terms, to limit the size of each production unit. Managers tend to be regarded as trustees of an institution; and explicit evaluation of human affairs is replacing implicit evaluation.

The P E P broadsheet is emphatic that, while industrial concentration has continued in the past few years, the dominant forces are now technological rather than financial or economic. Over many years such factors as the development of organized research and the advent of synthetic materials, with, as corollary, the huge initial investment demanded by new processes, have broken down traditional barriers between industries and stimulated the development both of the firm making a variety of products and of joint enterprises of several companies, not necessarily from the same industry. Both the inventive and financial resources of the nation are being canalized more and more through the large concern, whether publicly or privately owned.

The prime influence in this expansion across industrial boundaries has been the growing complexity of modern industry, under the influence, first of the chemical revolution in the second half of the nineteenth century, and later the development of synthetic products in the second and third decades of the twentieth. While the technical implications for different industries of such developments as plastics—'Terylene' and nylon, for example—have been adequately discussed, their impact on the industrial structure seems to have been neglected, and in directing attention to this as well as to the implications of such changes for the trade unions and for the human side of industry, the broadsheet does a real service. Moreover, it puts in its true perspective the seriousness of inappropriate taxation policies which discourage enterprise at a time when only the really large firm is in a position to carry the heavy overheads represented by research facilities and development from the laboratory, through the pilot plant, to full-scale production.

The broadsheet quotes sufficient examples of joint enterprise to indicate that the analysis of competition simply in terms of competing against other firms in the same industry is no longer tenable. The corollary that each firm is competing to a greater or less extent against every other firm in the economy holds social as well as economic implications far-reaching enough to warrant a comprehensive survey of industrial structure such as the broadsheet suggests. The suggestion is further supported by the trend of Mr. Duncan Sandys's recent statement in the House of Commons on progress in the development of the use of atomic energy for industrial purposes. Nothing in that statement encouraged the view that power obtained in this way is likely to be available on a significant scale for industrial purposes at an early date. Mr. Sandys was more concerned to emphasize the technical difficulties still to be overcome, and the need for much more experience before a considered judgment could be formed on the economic soundness of such proposals. None the less, social as well as

economic implications were indicated in the statement, and this underlines the value of the economic and social analysis of atomic power which was made by W. Isard and V. Whitney in the United States and which has recently been published in Great Britain under the title "Atomic Power: An Economic and Social Analysis"*. This study in industrial location and economic development is concerned mainly with the impact of atomic power upon the location of specific industries and the development of selected types of economy. The regional studies in this book suggest that generally the supply of capital, or some social factor, rather than energy, imposes limitations on progress. While there is little immediate prospect of atomic power becoming cheaper than the sources of power on which industry generally relies, in so far as atomic energy accelerates economic progress it is likely to do so most in the countries that would otherwise have become industrialized most rapidly.

The conclusion, accordingly, that international inequalities may well be increased rather than reduced by the non-military development of atomic energy is not one to be dismissed with unconcern in Great Britain. Articles in the *Bulletin of the Atomic Scientists* last November on private industry and atomic power pointed to the possibility of developments in this field changing the pattern of relations between government and industry in the United States. The same journal quoted a report of the Executive Council of the American Federation of Labour which indicated the existence of the same confused thinking on monopoly and industrial structure as is noted in Great Britain in the P E P broadsheet.

At least it is clear that in Great Britain, as in the United States, the development of atomic energy will demand much more than a high standard of technological ability on the parts of the scientists, technologists and industrial leaders directly concerned. Much will also be required of government and of management in the way of foresight and social and economic policy, as well as flexibility and adaptability; and these in addition to skill on the part of the industrial worker. If taxation policy, for example, handicaps or discourages development and enterprise, Britain is likely to fall still further behind in her technology and her consequent position in world trade. That will also happen if the industrial worker adopts a negative attitude towards changes in the technique or geographical pattern of industry.

It is against this dynamic background and the full realization of what the impact of technology upon society to-day demands of the leaders of industry as well as of the State, and of the ordinary worker and citizen, that a sound policy of technological education in Great Britain must be framed. It is not sufficient for its content to ensure that it provides the nation with technologists competent both to deal with the technical problems of development and to take account of the human and social issues involved. It is equally essential to implement a policy of technical education which provides technicians who are adaptable as well as proficient. Nor can we disregard the importance of seeing that, so far as is possible, the general education policy promotes the training of citizens who are likewise adaptable and are equipped to understand and to play their part in living in a technological society.

Quantitatively, policy in all three fields must be in balance. It would indeed be ill-judged to expand higher technological education to such an extent that both industry and the community in general could not draw from the universities sufficient leaders in other spheres, including those all-important studies into human relations and the development of the sense of community. The output of technologists and technicians must be related, as well as in some proportion, with the foreseeable industrial demand. A sound policy for technological and technical education must, in fact, start on the basis of quantitative estimates of demand. The wise apportionment of material resources, either of money or materials, can only begin on that basis. So far, however, the Government has given no sign that it has a policy for technical or for higher technological education in Great Britain. Such a policy must be conceived against a wide background of the social and national requirements of technological change and on a firm basis of ascertainable facts. Until that is done, it is idle to attempt to say how large or small a proportion of national resources should be devoted to the task.

* Atomic Power: An Economic and Social Analysis. A Study in Industrial Location and Economic Development. By Walter Isard and Vincent Whitney. Pp. xi+235. (London: Allen and Unwin, 1953.) 37*s.* 6*d.*

ALTERNATIVE SOFT FIBRES TO JUTE

Jute Substitute Fibres

Bimli-Jute, the Roselle and Aramina Fibre. By A. E. Haarer. Pp. xxi+185+57 plates. (London: Wheatland Journals, Ltd., 1952.) 30*s.* net.

THE author has gathered together a great deal of valuable information about three soft-fibre plants which are now being grown on an increasing scale as alternatives to jute.

Until recently, India and Pakistan held a complete monopoly in this class of fibre. The rich alluvial soils of the Brahmaputra and Ganges deltas, a suitable rainfall and temperature conditions, and a dense peasant population who knew how to cultivate this crop, all provided conditions which precluded any successful attempt to compete in other parts of the world.

During the past decade world conditions have changed. The uneasy conditions since the Second World War have led to stock-piling, political complications have arisen, and a serious threat to the food supply of Bengal has necessitated the diversion of more land from jute to rice. All these factors have resulted in a dislocation of the normal channels of the jute trade and have contributed to fluctuations in price. When it is further remembered that world demand has also increased, a natural corollary has been an urge to establish alternative sources of supply.

The places outside Bengal where climatic and soil conditions favour the growth of jute are limited. Parts of Brazil, British Guiana and the Niger delta are possibly the most promising; but in these places the shortage of labour would present a major obstacle to progress, if the methods employed in Bengal were to be relied on. Further developments, therefore, would seem to depend on whether it is possible to replace hand labour by mechanization, especially in connexion with harvesting and fibre extraction. Experiments in these directions are now being made; but in the meantime increased consideration has been given to the possibility of producing fibres which could be used as substitutes for jute, and at the same time would not need the exacting conditions required by that plant. In recent years, progress in this direction has proceeded apace for, as Sir John Russell states in his foreword, "in the world of reality it is dangerous to rely on monopoly production".

The three fibre plants considered by the author as the most promising jute substitutes are all tropical or sub-tropical members of the great family Malvaceæ. Bimlipatam jute or kenaf (*Hibiscus cannabinus*) ranges farther into the sub-tropics than either roselle (*H. sabdariffa*) or aramina (*Urena lobata*). All possess an advantage in that they can be grown under a much wider range of conditions than jute, and are not therefore so limited in area. The author deals with this aspect in considerable detail. It is interesting to note that all three species occur as wild plants and are found in widely separated localities in Africa and Asia in particular. Under such conditions of dispersion, there are, as might have been expected, a large number of varieties affording a fruitful field for the plant breeder and resulting in the segregation of types specially suited to particular districts. Much experimental work has also been undertaken in this field and, in fact, it might almost be stated that the stage has now been reached when satisfactory crops, both as regards yield and quality, can be anticipated with reasonable certainty.

The growing of the crop is not, therefore, the big difficulty; that lies in the problems of extracting the fibre at a reasonable cost. In central India, ambari (as Bimli jute is called in the Mahratha country) is grown by peasant farmers as a secondary crop in small patches, and the stems are harvested and retted and the fibre extracted by hand. But if fibre is to be produced on a large scale for commercial purposes, such methods are not adequate and some form of mechanization will be required. Considerable space is devoted to these problems by the author, and they form a valuable section of the book. As an illustration of the kind of problem that has to be overcome, the case of Bimli jute, which is the most widely grown of the three species, may be taken as an example of the problems involved. The best time to cut the crop is the short period of, perhaps, ten to fourteen days between the appearance of the first flower and the first seed-pods. If cut before flowering, the fibre is immature and, if cut after seeding, the stems are hard and the fibre difficult to extract. *H. cannabinus* reacts to photoperiodicity, and, when the hours of daylight decline to a certain period, the plant automatically goes to seed. The problem, therefore, is so to arrange matters with regard to labour and decorticating machinery that as much of the crop as possible can be handled in this set period. The author describes in some detail the various measures that are being attempted to deal with this problem. The modern view tends towards discarding the old method of stripping the fibre after retting and to substitute decortication of the stems by mobile machines.

These decorticating machines, however, can only deal efficiently with the green sappy stem, and it seems probable, therefore, that they will have to be supplemented by some adaptation of the retting method. The serious drawback to this, apart from the need for an ample water supply for retting, is the cost of transporting the crop in bulk, for the green stems only contain some 5–6 per cent of fibre.

A chapter is devoted to diseases and pests, and the text is well documented. There are no less than fifty-three illustrations and four coloured plates illustrating varieties of both species of *Hibiscus*, together with thirteen sketches and diagrams.

The book can be safely recommended as a valuable work of reference, as it brings together much scattered information on recent developments. G. Evans

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THE AMERICAN CHEMICAL SOCIETY, 1876–1951

A History of the American Chemical Society Seventy-five Eventful Years. By Charles Albert Browne and Mary Elvira Weeks. Pp. xi+526. (Washington, D.C.: American Chemical Society, 1952.) 5 dollars.

THIS book will be read with interest not only by those who attended the seventy-fifth anniversary of the American Chemical Society in New York during September 1951, but also by all American and British chemists. To British chemists in particular the volume contains much of interest. Not only does it list the Royal Society as the first scientific association in which the activities of American chemists participated, but John Draper, a Liverpudlian, was the first president of the American Chemical Society, and the Priestley centennial meeting was the first American chemical congress which was truly national in character.

As the contents of the book reveal, it is a pleasant and, in the present state of world affairs, a hopeful sign that Anglo-American co-operation has not yet ceased. It is interesting to note that round about 1900 the membership of the British chemical societies was, according to Dr. Bolton, some seven thousand seven hundred, and of the United States societies some two thousand five hundred, while at the present time the American chemical societies list more than sixty thousand members.

In common with other scientific societies, especially chemical ones which appear to contain an undue proportion of highly individualistic characters, the growth of the American Chemical Society was not a smooth one, but to achieve a coherent society of such a size was a remarkable achievement. In this volume the reader is given an excellent account of the ramifications of the Society's activities and the problems with which it has to deal. It is evident that the organization has been robust and also sufficiently elastic to cope with the present-day almost insuperable problems associated with scientific publications and with the general planning of meetings which the Society is facing at the present time.

Societies grow if they fulfil a need; how they grow, and how useful they are, are factors which are usually determined by the efforts of a few earnest

workers in the Society. In this volume excellent photographs are reproduced of all the presidents past and present of the Society; some of these are, or were, personally known to their British colleagues both for their activities as chemists and for their participation in the Society's activities; but it is highly likely that the name of Charles L. Parsons is known to more chemists in the world than any other associated with the Society's activities. It is probable that the membership of the American Chemical Society by now exceeds the total membership of all other chemical societies outside the Iron Curtain, and one can look forward with hope and enthusiasm to the first centenary of the Society.

ERIC K. RIDEAL

THE STERLING AREA IN AMERICAN EYES

The Sterling Area

An American Analysis. Prepared under the direction of John M. Cassels. (Published by the Mutual Security Agency Mission to the United Kingdom.) Pp. 672. (London: H.M. Stationery Office, 1951.) 21*s*. net.

WHEN the Economic Co-operation Administration mission to the United Kingdom began to function in 1948 it immediately felt the inconvenience of its lack of knowledge, not only of the United Kingdom economy but still more of the economies of other British Commonwealth countries and of that strange and amorphous organization summed up as 'the Sterling Area' with which they are financially linked. The information the mission sought was not easily available anywhere, and it was an excellent idea to get together a fact-finding committee to write an objective report on the various members of the Area, from the point of view both of those who had to administer Marshall Aid and of the American public, who might be expected to contribute more willingly if they understood better to what they were contributing. The result is a handsome volume, sumptuously printed in Amsterdam, with innumerable illustrated statistics, some of which are in colour, and a wealth of tables. It contains 671 double-column pages and weighs 5½ lb.

The American passion for large publications is very difficult for the British to understand, and this one is (as it would no doubt be described in the United States) a 'jumbo' even by American standards. It is divided into three parts, described as books. The first summarizes the main features of Sterling Area countries; one chapter describes briefly the United States and Canadian economies by way of contrast and by showing their relations to the Sterling Area. A brief summary of the extent and progress of post-war recovery is then given, and the book ends with what is effectively a review of the Sterling Area considered as a proposition for American investors.

Book 2 consists of a series of lectures on economic geography at a fairly elementary level, going carefully around the components of the Area and summarizing their economic structure: population (size, growth and racial structure), imports and exports (pre- and post-war, by commodity and by country of origin or destination), external capital position and domestic economic policies. Book 3 consists of thirteen chapters, each of which is devoted to describing the world position in respect of some commodity or group of commodities (primary products) important in world trade. This is done with a considerable degree of detail. For example, the chapter on non-ferrous metals gives first a table for twenty non-ferrous metals of United States consumption as a percentage of world, and of United States production. This is followed by an immense table of the production (by weight of metal content) of each of twenty-five non-ferrous metals in each of sixty countries of the world. This in turn is followed by individual studies of tin, copper, aluminium (including bauxite), lead and diamonds.

It will be evident that Books 2 and 3 contain a great deal of information, some of which is not easily available elsewhere and more of which is conveniently brought together for the first time. Most of the information has, inevitably perhaps, been snipped out of books and legal documents (such as the constitutions of the various countries). This matters less in Book 3 than in Book 2, where this type of second-hand knowledge, although not actually incorrect, can give a distorted impression, in that practice often develops a very different emphasis from that apparent in the legal framework. A short visit by a member of the committee to a few leading Sterling Area countries (such as India) would have served to correct this. Again, an over-concentration on trade statistics not infrequently gives a misleading impression, for example, in the case of Ireland, where invisibles in both directions play such an important part in the balance of payments.

The sub-title of the work is "An American Analysis"; this does it both less and more than justice. There is virtually no analysis in the economic sense. On the few occasions when an economic argument is put forward, it tends to be incomprehensible (as when it is stated that devaluation was favoured because it would make British industry more efficient under increased competition from American exporters). The statistics are all of a very 'bread and butter' type and should not be relied on in too great detail.

On the other hand, the study tries very hard (and on the whole succeeds very well) to attain a strictly fair and objective attitude, and to keep American prejudices against the Sterling Area well in the background; indeed, the book should do much to dispel them. Nevertheless, from the British angle the view is, of course, American. For example, the discussion of the change in the position of South Africa, and hence indirectly of the whole Sterling Area, due to the failure of the price of gold to get adjusted to post-war levels, is delicately skated over. Again, while the Sterling Area restrictions on dollar imports are set out at length, there is much less of dollar restrictions on Sterling Area exports, such as tin.

Nevertheless, the British reader will find in the book much that is new to him and on which he would do well to ponder. Especially important is the demonstration of the increased direct dollar earnings of Sterling Area commodities—by-passing the traditional triangle through the United Kingdom (Australian wool is an important example). Such changes as these are very largely the source of the increasing strains which are all too evident in the rigid organization of the Sterling Area. It is vital that we should have them impressed on us in order that they may be relieved before it is too late.

URSULA K. HICKS

RUMFORD: A BICENTENARY

By THOMAS MARTIN

BENJAMIN THOMPSON, afterwards Count Rumford, was born two hundred years ago (March 26, 1753) at Woburn in Massachusetts, about fifteen miles from Boston. Distinguished as a soldier, a statesman, a philanthropist and a man of science, it is probably in the last of these characters that he is best remembered to-day. He made experiments and reached conclusions of fundamental importance concerning the nature of heat; he was the author of a series of "Essays" on various subjects in pure and applied science which were well known and widely circulated in their day; he was a pioneer in that field of activity which he himself described as the "application of science to the common purposes of life"; and in the pursuit of this object he founded the Royal Institution in London.

Rumford came of the Puritan stock of the original New England settlers, and widely though he departed, in the course of an active and at times adventurous life, from the ways of his forefathers, there is no doubt that their traditions left their mark on his character. Added to his intellectual gifts were a methodical industriousness and a frugal outlook which caused him to take an intense interest in the practical details of his schemes of welfare, while in his personal relations there was often a harsh disregard for the feelings of individuals which was in marked contrast with the professed object of his plans; and it is probably in these characteristics that we may trace his New England origin.

His early life was lived in those troubled years in the American Colonies which led up to the War of Independence. While working as apprentice to a storekeeper, he showed an interest in science and experiment, and attended lectures at Harvard. Later, as a young schoolmaster at Rumford (later Concord) in New Hampshire, he married the widow, fourteen years his senior, of a considerable citizen of that place. It was here that his daughter Sarah, afterwards Countess Rumford, was born.

His military aspirations were gratified when he was commissioned as major in a local regiment of militia; but he was suspected by the townspeople of sympathies for the royalist cause which were too ardent for their liking, and when the troubles came to a head he was obliged to escape from the town. Later, to avoid persecution, he joined the British in Boston, leaving his wife, whom he was never to see again. Henceforth he was an avowed loyalist.

On the evacuation of Boston, Major Thompson was sent with dispatches to London, and before long, such was his initiative and address, was established in the Colonial Office as an under-secretary to the Minister, Lord George Germain. His promotion was rapid. The United States had declared their independence on July 4, 1776; but the war dragged on, and for a time Thompson returned to America, to serve with some distinction in command of a regiment of cavalry with the British forces. Peace was not finally concluded until 1783, when he found himself again in London, a colonel with half-pay on the British establishment.

Seeking fresh fields to conquer, Thompson visited the Continent, and after a brief return to Britain, during which he was knighted by King George III, there followed that most active and fruitful period of his career when for fourteen years he served the Elector of Bavaria. It was in Munich, where he held high military rank and was Privy Councillor of State to the Elector, that his constructive energy and administrative skill found their full outlet. The country was backward and the administration inefficient and corrupt, and Sir Benjamin Thompson's New England soul must have revolted at the incompetence and neglect he saw around him.

He introduced reforms in the army and in many of the Departments of State; but in none of his measures was he more successful than in those for dealing with the problem of mendicancy. After a period of war and political disturbance, the country was infested with beggars whose menaces and extortions seriously alarmed the law-abiding citizens of Munich. Thompson appointed a day when, with the aid of the military, all the vagrants in the capital were arrested. Houses of Industry having been prepared for their reception, and a charitable organization set up to provide the necessary funds, the genuine poor and infirm were relieved and the able-bodied set to useful work. By his enlightened and humane treatment of the destitute and the originality and success of his methods in the Houses of Industry, he established a new system of philanthropy, and his ideas were afterwards applied, often on his personal advice, in many other countries.

This work in Munich aroused his interest in such matters as economy of fuel, the design of stoves and fireplaces and the economical provision of food for large numbers of people; and many of his "Essays", published later, were devoted to these subjects. Rumford stoves were widely used and Rumford soup kitchens set up in London, Paris, Geneva and elsewhere; the soup tickets could be purchased by the charitable and given to the hungry.

The Elector Karl Theodor rewarded Sir Benjamin Thompson by creating him a Count of the Holy Roman Empire, and the new Count took for his title the name, Rumford, of the place in New Hampshire where, after his marriage, he had first been established as a man of substance.

He returned to England in 1798, expecting to be the Bavarian Minister in London, and was grievously disappointed when he found that the British Government would not accept a subject of the King as the representative of a foreign power. He stayed on in London, however, where his fame had travelled before him: William Wilberforce declared in Parliament that it was "a public blessing in such times as these to have such men as Count Rumford" in the country. The Count became a leading member of a group of practical philanthropists, associated in the Society for Bettering the Condition and Increasing the Comforts of the Poor, who were responsible at this time for a number of new enterprises. One of these, the principal object of which was to be the application of science and invention to the improvement of the lot of the working classes, was the Royal Institution; and to this establishment, founded in 1799, Rumford devoted most of his time for upwards of two years.

Rumford's fame during his life-time rested on his public works, and the special feature of his activities,

which distinguished him from other professed reformers, was his determination to apply scientific knowledge to the objects of philanthropy. Much of his scientific work had a strictly utilitarian object in view. Throughout the period of his service in Bavaria, however, and indeed all through his life, he returned, in the intervals of his public labours, to the "more pleasing occupations of science and philosophical experiment". These private researches formed the subject of his periodical communications to the Royal Society and other learned bodies, and it is upon them that his enduring reputation as a man of science really depends.

As early as 1778 he carried out in England a series of experiments with gunpowder and firearms. The paper describing this work shows that he was well acquainted with the work of Benjamin Robins, the inventor of the ballistic pendulum, and he used a Robins pendulum to determine the velocities of projectiles. A chance observation of the greater heating of a gun-barrel with a blank charge than when a projectile was fired led him to investigate the source of the heat, and although his explanation of the observation is not very convincing, it shows that he had already begun to think in terms of the generation of heat by mechanical action and to speculate as to the nature of heat itself.

He had made the acquaintance of Sir Joseph Banks and other men of science soon after his arrival in England; and in 1779 was elected a Fellow of the Royal Society.

On a visit to Mannheim in 1785, he made some experiments on heat at the Academy of Sciences. A thermometer was fixed at the centre of a glass tube having a bulb at the end, the bulb immersed in ice or boiling water, and the times noted for the thermometer to fall or rise through certain intervals of temperature. With this apparatus he obtained measures of the conducting power of the contents of the bulb—water, mercury, air at different pressures—or a vacuum. His discovery of the heat-insulating power of a vacuum, or more accurately the reduced conductivity of the imperfect vacuum he obtained, is of particular interest, for it contains the suggestion of the principle used many years later by Sir James Dewar in his vacuum vessels. Another important observation was that moist air conducts more readily than dry.

The experiments begun in Mannheim were continued in Munich, and a more elaborate apparatus devised, which has been erroneously described as Rumford's calorimeter, but which he called his "cylindrical passage thermometer". It was an instrument for measuring conductivity, and with it he made a great many determinations. One of these instruments is preserved at the Royal Institution. The discovery of the superior conductivity of moist air prompted him to measure the moisture absorbed by the materials of clothing and its effect on their heat transmission; and in his paper to the Royal Society on this subject there are observations on the evils of a damp climate and the dangers of sleeping in a damp bed. He was a firm advocate, too, of woollen clothing worn next to the skin, to absorb the moisture, and had no patience with the idea that it was too warm or too irritating a material for the hot weather.

An observation that, by obstructing the free circulation of air, its power of communicating heat could be reduced, led to a new inquiry. Other fluids were examined. He tells us that he had always been struck by the extraordinary capacity of stewed apples to retain their heat. Like others, he had burned his mouth with hot apple pie; and he found on experiment that stewed apples, containing actually very little solid matter, were a much poorer conductor than pure water. From this it was a simple step to obstruct the circulation of water artificially, with fragments of solid materials, and in this way he discovered the important part played by convection in the transfer of heat. With a suspension of powdered amber in an alkaline solution adjusted to the same specific gravity, he went on to make a systematic study of the convection currents in fluids on heating, and reached important conclusions.

Rumford's investigation of the propagation of heat in fluids, and particularly his discovery in these simple experiments of the important part played by convection, is one of his most valuable contributions to the science of heat. His enthusiasm for his discovery led him, however, to make extravagant claims. He convinced himself that air, water and other fluids were actually non-conductors. All heat transfer was by convection, and there could be no conveyance of heat in a fluid at rest; a conclusion which not unnaturally involved him in controversy.

Being in need of a method of comparing the amounts of light emitted by the lamps in a factory in Munich, Rumford devised an instrument for the purpose in which the positions of two lamps could be adjusted to throw equal shadows of an object on a screen. This device, which proved to be thoroughly effective and practical, was the first shadow photometer, described in Glazebrook's "Dictionary of Applied Physics" as "the earliest form of photometer capable of accurate work".

Rumford also made important observations on radiant heat. He was surprised to find that a vessel of polished brass containing hot water cooled quicker when it had a covering of linen than when it was uncovered, and was led to examine surfaces in relation to their loss of heat by radiation. He discovered that a blackened surface gave off heat far more readily than one of polished metal; and he saw at once the practical bearing of this observation, advocating polished metal dishes for serving hot food and black-painted pipes for steam heating. For the accurate comparison of the radiation from different surfaces he devised another new instrument, a differential thermometer or 'thermoscope', consisting of a glass tube with bulbs at the ends, containing air, with a 'bubble' of spirit in the tube the movement of which could be measured when the radiating bodies were presented to the bulbs.

The best known of all Rumford's experiments, made with a cannon and boring tool in the Arsenal at Munich, is so familiar that it need not be described here in great detail. It resulted in a short paper, on the source of the heat which is excited by friction, which contributed more to his scientific fame than any other part of his work. The blunt boring tool was held fixed, and entered a cavity turned in the end of a casting for a cannon; the end of the casting, separated from the main part by a narrow cylindrical neck, was enclosed in a box containing water. When the cannon was rotated by horses, after two hours and a half the friction of the borer caused the water to boil.

To the onlookers, this was a spectacular demonstration. For Rumford, the measurements and observations he made convinced him that any theory, such as the caloric theory, which attributed

material properties to heat, was no longer tenable. To quote from his paper: "It appears to me to be extremely difficult, if not quite impossible, to form any distinct idea of anything capable of being excited or communicated in the manner the heat was excited and communicated in these experiments, except it be motion"; motion, that is, of the constituent particles of the heated body. He claimed no originality for this conception; but the investigation confirmed his views, held in opposition to many of his contemporaries, on the nature of heat and its relation to mechanical action; it had a decisive effect in overthrowing the caloric theory, and it paved the way for the later conception of heat as a form of energy and the measurement of its mechanical equivalent by J. P. Joule.

A good deal of controversy was aroused by Rumford's published researches. Berthollet endeavoured to explain the cannon-boring experiment on a caloric basis. Men of science in Great Britain, while they accepted his demonstration of the part played by convection in the propagation of heat, rejected his view that fluids were non-conductors. John Dalton condemned this theory, and repeated Rumford's experiments in his own way to prove that fluids could conduct. Nevertheless, he expressed high appreciation of the demonstration Rumford had given that convection currents were the main cause of the diffusion of heat in fluids. Others less discerning than Dalton saw nothing but error and even hypocrisy in his writings. A spiteful article in the *Edinburgh Review* accused him of 'borrowing' and claiming as his own the invention of the differential thermometer from Leslie. Rumford was obliged to write a "Historical Review" of his work on heat to defend himself, which is remarkable for its moderation compared with the ill-natured criticism which was levelled at him.

Rumford made mistakes, due in part to his isolation and ignorance of what others were doing at the time he was making his own experiments, and he laid himself open to criticism by the prolixity and repetition of which he was often guilty in his writings. But later generations have endorsed the opinion of Dalton, and given credit to him for what was new in his experiments and valuable in his theories on the nature of heat.

In 1802 he left England again, to settle in Paris, where he married the widow of Lavoisier. The marriage proved unhappy, and he retired to a villa at Auteuil, where he carried on his experiments. Although pressed to do so by friends, he never returned to America. He died in 1814.

RUMFORD AS A SCIENTIST

IN a Friday Evening Discourse delivered at the Royal Institution on March 27, Sir Eric Rideal gave an account of the life and work of Rumford. The Discourse was accompanied by experimental demonstrations of many of Rumford's investigations. The following account indicates the great width of his purely scientific interests.

Rumford's name is generally associated with his experiments on heat. In his day the nature of heat was a subject-matter of controversy. According to one view, heat was a material substance termed 'caloric' which, fluid-like in character, could penetrate all space, was self-repulsive, and was strongly attracted by matter. On the other hand, heat was regarded by Boyle and Hooke as a form of energy, a 'mode of motion'. Rumford's experiments in support of the energy theory were very far-reaching and embracing. The experiments on boring cannon which he carried out in Mannheim are well known.

Later, Rumford devised a simpler apparatus in which by friction between metal plates he was able to heat water surrounding the plates. He showed that the supply of heat generated in this way was inexhaustible, and he could detect not the slightest change in either the weight or specific heat of the system. It is interesting to note that his experiments led to the value of 1,034 ft.-lb. as the amount of work required to raise the temperature of 1 lb. of water by 1°, while Joule's later more precise measurements gave 772 ft.-lb. Rumford himself believed his value to be an over-estimate. He was thus the first to determine the mechanical equivalent of heat.

Rumford was the first to show that heat could travel through a vacuum, that is, in the form of radiation. He showed that radiation could take place more readily from blackened surfaces than from polished metals. He likened this radiation to the acoustic waves given off by a bell when struck, and believed that the radiation of cold or frigorific radiation, although different from the radiation of heat, yet obeyed the same laws. In 1800 Rumford repeated in the Royal Institution the experiments of Pictet on focusing cold by means of mirrors, an experiment shown here repeatedly by Tyndall. To Rumford we are also indebted for the discovery of the transport of heat by convection. He demonstrated the existence of convection currents by suspending powdered amber in dilute caustic soda of the same specific gravity as the amber. When a cylinder containing this suspension was plunged into boiling water, the convection currents rising at the sides and moving downwards at the axis were clearly seen. This experiment was published in his seventh essay in 1797, but it was not until 1834 that Prout gave the name 'convection' to this method of heat transport.

The stoves invented by Rumford for domestic heating have often been mentioned. He observed that only one-fifth of the heat generated by the fuel is radiated into the room; the rest goes up the chimney. He showed that the most effective angle between the sides and the back is 135°, and the width of the back only one-third of the front opening, the back and sides rising perpendicularly until they joined the breast of the fireplace, while the throat of the chimney was to be only about four inches wide. The increase in warmth was found to be one-half to two-thirds as compared with the traditional open fireplace.

> Lo every parlour, drawing room I see
> Boasts of thy stoves and talks of nought but thee.
> Yet not alone my Lady and Young Misses,
> The cooks themselves could smother thee with kisses.
> Yes, Mistress Cook would spoil a goose, a steak,
> To twine her greasy arms around thy neck.

In Paris Rumford devoted himself to improvements of the Argand burner and to the construction of a calorimeter in which the products of combustion passed through a serpentine tube immersed in a known volume of water—indeed, a very modern device. He displayed eccentricity by wearing white clothes in winter, since these radiated less heat than

dark ones. In these clothes he drove around Paris in a coach with extra broad rim wheels made to his own design. Here, however, he made himself unpopular with the French scientists, especially with Laplace, with whom he also differed in views regarding surface tension.

In 1782, Argand greatly improved oil lighting by utilizing a hollow cylindrical wick which permitted air to be drawn up on each side of the wick. As in modern paraffin lamps, the burner was situated above the oil reservoir. At that time only colza and similar high-viscosity burning oils were available, and, in consequence, the height of the flame was small owing to the low rate of capillary ascent. Rumford improved the lamp by feeding the oil from a circular reservoir maintained at the same height as the wick. In 1800 the reading and lecture rooms of the Royal Institution were illuminated with the new Rumford–Argand lamps.

For testing the most suitable shade to be made, as Rumford states, "of such substances as disperse light without destroying it", he devised the candle photometer, still in use to this day. Rumford at a later date designed a portable lamp with a flat wick, and several of these are to be found in the museums in Massachusetts.

Rumford published several papers on capillarity and demonstrated for the first time the now well-known experiment of flotation of a needle at an air-water and at an ether–water interface. He concluded that liquids such as water are bounded by a pellicle on which the needle can rest, and that air retention under the needle is not the seat of the mechanism of flotation, as was suggested at the time. We now know that the molecules in the surface layer of a liquid are a little farther distant from one another than those in the bulk phase, and if they are so separated there must be net attractive or cohesive forces operating between them; thus the concept of a pellicle was not so erroneous as Laplace supposed.

ORIGIN OF ACQUIRED DRUG RESISTANCE IN BACTERIA

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Variation in Micro-organisms

It is characteristic of micro-organisms that they readily become adapted to changes in environment. This plasticity shows itself in such ways as the development of highly specific virulence or of the ability to grow in unusual media. In undergoing this adaptation, it is sometimes possible for new strains to arise differing considerably from the original strains.

The problem of the mechanism by which such induced variations are brought about has been the subject of much speculation during the past twenty years or so. Particular attention has been given to the induction of variation by changes in chemical environment, the most notable examples being the induction of specific enzymes ('enzyme adaptation') and the induction of resistance to drugs ('acquired drug resistance'). It was while working in this field of enzyme adaptation that I described and distinguished the two most likely mechanisms of induced variation[1]. One of these was at that time called simply adaptation; a better term would be direct induction. This postulated that the change was directly induced in (potentially) all the cells by an interaction between the cells and the new chemical environment. An example of this is the induction of the ability to ferment galactose in some species of yeast which are normally unable to do this[2,3].

The second mechanism by which induced variation might be brought about was originally referred to as 'training'. This postulated the occurrence in a culture of rare mutants having the character of the new strain; the effect of the new chemical environment was entirely selective, in that the mutant cells, but not the non-mutant cells, were able to grow in it. Likely examples of mutation with selection are the occurrence of lacto-fermenting strains in *Bacterium coli mutabile*[4] and the development of strains of *Staphylococcus aureus* highly resistant to streptomycin[5]; it is still not certain, however, that these are not in fact examples of direct induction[6].

It is, of course, possible that both mechanisms may occur simultaneously, so that the new chemical environment both induces a change and selects it. Apart from this possibility, however, all workers in the field of induced variation in micro-organisms have considered only these two possible mechanisms. This is especially noticeable in the problem of acquired drug resistance in bacteria. Demerec[5,7] considers that the effect of a drug in producing resistant strains is in selecting rare spontaneously arising resistant mutants. On the other hand, Hinshelwood and his co-workers have in a large number of publications taken the view that drug resistance is similar to, and is indeed a form of, enzyme adaptation which can occur in potentially all cells. The drug induces in each cell a change in enzymatic structure which enables it to carry out essential metabolic processes, for example, by producing alternative pathways to those blocked by the drug.

The assumption universally made, that there are only two possible mechanisms by which variations may be induced in bacterial cultures, has led many workers to support one theory by criticism of the other. For example, Hinshelwood frequently points out that the theory of mutation with selection would require a number of assumptions which he considers unlikely; in consequence, the theory of direct induction is preferred as being simpler, more plausible and more economical in unproved assumptions.

The fact that the debate has continued for many years is partly because the technical aspects of the work do not lend themselves to crucial experiments which can decide the issue. In some instances of enzyme adaptation, it has been possible to induce the change in cells that are virtually not dividing, which must imply direct induction. In acquired drug resistance, however, it seems to be necessary to grow organisms for many generations, often with numerous sub-cultures, in order to induce the change. Clearly, it is possible in these circumstances for either mutation with selection, or slow direct induction, to act in producing the change.

In spite of these difficulties, I suggest that there are now sufficient experimental facts to throw doubt on both of the currently accepted theories in so far as each attempts to explain completely acquired drug resistance in bacteria. A third theory is proposed which, it is claimed, is in conformity with existing knowledge, and lends itself in some measure

to deductions capable of being tested experimentally. Before, however, describing this new theory of 'clonal variation with selection', it will be profitable to examine in a little more detail some of the facts known about the phenomenon of acquired drug resistance.

Essential Features of Acquired Drug Resistance

(1) An organism, sensitive to a given concentration of drug, may acquire a resistance to this or to higher concentrations if it is grown in the presence of the drug. Occasionally, maximal resistance is attained by one sub-culture in the presence of drug; more often, increasing resistance is achieved by sub-culturing in increasing concentrations of drug. By limiting the concentration of the drug to a value below the maximal, it is possible to attain resistance to intermediate concentrations.

(2) The apparent resistance of a culture varies with the size of the inoculum used. That is to say, the concentration of drug in which the organisms will grow will be larger if a larger number of organisms is inoculated into it.

(3) The training of the organisms to grow in otherwise lethal concentrations of drug involves not only the mere ability to do so but also an increase in the ease with which they grow. This is shown by a gradual reduction in the mean generation time and in the lag, and an increase in the size of colonies on solid media, as the process of training is continued.

(4) When a resistant culture is grown in the absence of drug, reversion to non-resistance may occur. This may be a complete reversion to a culture as sensitive as the original, or it may be a partial reversion to a lower degree of resistance. In some instances, no reversion occurs, and the degree of acquired resistance is retained. The last possibility is more likely to occur if the trained cells are repeatedly sub-cultured in the presence of the drug very many times.

Interpretation of Essential Features according to Current Theories

Let us now examine the current explanations of these facts according to the two theories of direct induction and mutation with selection.

(1) *Graded resistance.* The fact that a culture may be made resistant to a chosen concentration of drug is in conformity with the theory of direct induction, since it is known that the degree of enzyme adaptation by direct induction is dependent on the concentration of the inducer[2]. The theory of mutation with selection must here postulate a number of step-wise mutations. Since the degrees of acquired resistance may in some instances vary by very small steps over a wide range, one must postulate many mutational steps. If one adds that such step-wise resistance may be acquired by one organism for a number of known drugs as well as no doubt for a much larger number of drugs which have not yet been examined experimentally, it can be appreciated why Hinshelwood casts doubt on the theory of mutation with selection.

(2) *Size of inoculum.* Direct induction involves the concept of opposing factors simultaneously affecting the bacteria over a period of time. On one hand, the drug stimulates the cells to produce the enzymatic adjustment necessary to by-pass the drug-blocked systems. On the other hand, the drug causes the death of continuously increasing numbers of cells. Thus the larger the number of cells inoculated into the drug-containing medium, the greater will be the chance that some will develop the necessary enzymatic equipment to grow in its presence. The theory of mutation would merely suggest that the chances of a drug-resistant mutant being present is obviously larger in a larger inoculum. It is not easy to see, however, why there should be a continuous apparent increase in the degree of resistance with increasing inocula.

(3) *Rate of growth of trained cultures.* We have seen that, in the presence of drug, cultures at first grow slowly. The rate gradually increases if they are sub-cultured into the same concentration of drug; but it often occurs that, even after prolonged training, they still grow slower in the presence of drug than in its absence. Direct induction would no doubt explain this on the basis of the increased strain put upon the organisms in developing the alternative enzymatic systems. The mutation theory simply states that the resistant mutants are slower-growing variants.

(4) *Reversion.* According to the theory of direct induction, a trained culture will or will not revert to the original sensitive strain depending on whether the induction has or has not been sufficiently 'impressed' upon the cells. After a moderate degree of training, for example, twenty passages in the highest concentration of proflavine, Hinshelwood found a rapid though incomplete reversion when cultures of *Bact. lactis aerogenes* were grown in the absence of drug[8]. However, after eighty passages in the presence of proflavine, resistance persisted during many sub-cultures in the absence of proflavine. Hinshelwood postulates that the earlier stages of direct induction involve some mechanical strain in the organism. When the strain is released by growing the cells in the absence of drug, the new enzyme systems partly regress to reach a stable level associated with the mild resistance of an equilibrium state. The later stages in prolonged induction, however, gradually produce more complex changes which stabilize the new enzyme systems, and so permit the retention of full resistance, even in the absence of drug.

The theory of mutation with selection explains reversion as being due to back mutation or the incomplete elimination of non-mutant cells, together with the selection of non-resistant cells when they are assumed to grow faster than the resistant strains. That prolonged training may result in cultures which do not easily revert is to be explained by a parallel selection of faster growing mutants with selection of the resistant mutants[9,10].

Theory of Clonal Variation with Selection

The theory of clonal variation with selection is based on one assumption. This is that a bacterial cell, of whatever resistance, may give on division two cells with different and unequal resistance. For

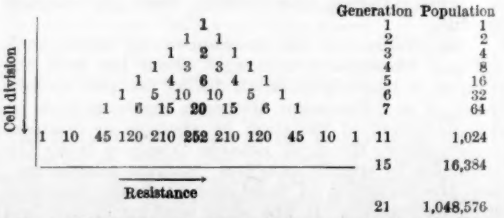

Fig. 1. Distribution of resistance in the progeny of a single cell in *absence* of drug

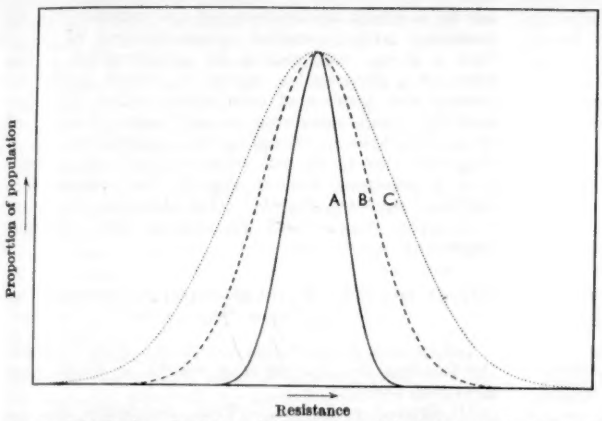

Fig. 2. Distribution of resistance in populations of bacteria grown in *absence* of drug. *A*, cu ture from single cell; *B*, after a few sub-cultures; *C*, after several sub-cu tures—'permanent' form of distribution curve

this to occur, it is only necessary to imagine that at division the systems responsible for drug resistance are not necessarily distributed in equal amounts between the daughter cells. Within limits which will be defined later, the result is a clone of cells the average resistance of which is that of the parent cell, but with a distribution of resistance of the members of the clone around that of the parent cell.

Model of Acquired Drug Resistance by Clonal Variation and Selection

It is reasonable to suppose that the probability of an unequal distribution of resistance in daughter cells on division is inversely proportional to the size of the inequality. That is, the dividing cell is most likely to give two equally resistant cells, less likely to give cells of slightly different resistance, and least likely to give cells of very different resistance. The resultant clone from a single cell would thus have a resistance in its members which would be of a Gaussian or similar distribution. For our simple model, however, we shall assume that division always occurs with balanced asymmetry, one daughter cell having a higher resistance by a fixed small amount, the other having a lower resistance by the same amount. Repetition of this process produces a family of cells with binomial distribution of resistance (Fig. 1).

With given conditions of composition and volume of medium and of time of incubation, the population from a single cell will be composed of cells of varying resistance, the proportions of which are distributed according to the curve *A* in Fig. 2. A small volume taken from this for inoculating into a fresh amount of medium would be likely to contain cells of the 'peak' of this curve, and not contain the rarer cells of high or low resistance. Thus an inoculum the volume of which is one-thousandth of the whole medium is not likely to contain cells the frequency of which is much less than one-thousandth of the total population. Nevertheless, the inoculum will contain some cells of higher and some of lower resistance than that of the original single cell. The population arising from this in the second volume of medium will therefore have a wider spread of resistance, something like curve *B* of Fig. 2.

During further sub-cultures, the spread will increase until it reaches a degree which we may represent by curve *C*. If we assume that we have used standard conditions of inoculum, volume of medium, time of incubation and the like in our sub-culturing, we now find that no further spread of distribution in resistance occurs in later cultures. The spread among the cells of our inoculum increases during growth to give curve *C*, but no further; it is cut short when growth ceases in the limited medium, or when the culture is discarded after an inoculum is taken. Thus the standard inoculum for subsequent cultures will contain cells of the same degree of spread. Curve *C* thus represents the sort of distribution that will exist in a culture normally being used in the laboratory.

When an inoculum is made into medium containing drug, of a concentration in which only the more resistant cells from the inoculum can grow, a situation will arise of which the earliest stages are represented in Fig. 3. In this, we see what occurs in a cell with a resistance just greater than that represented by the concentration of drug present. The drug acts as a 'bar', killing or at least preventing the growth of those cells which, because of 'clonal variation', have a resistance below that represented by the concentration of drug. As a result, only those cells to the right of the bar are able to grow, and a continuation of the process indicated in Fig. 3 can be shown to give a population of cells with a distribution of resistance shifted to the right. Eventually, after very many generations involving many sub-cultures, the shifted distribution curve will be similar in form to that of the original culture (Fig. 4).

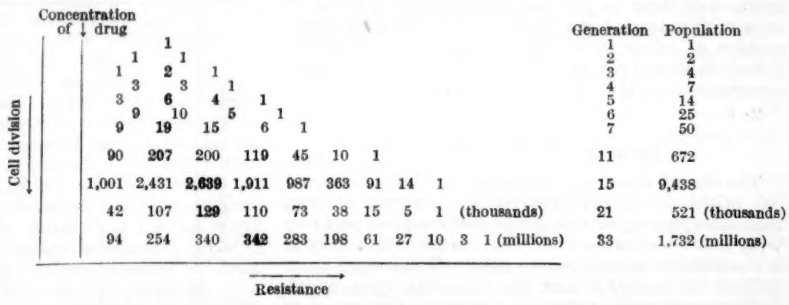

Fig. 3. Distribution of resistance in the progeny of a single cell in *presence* of drug with concentration just below resistance of the cell. Comparison with Fig. 1 shows three effects produced by the drug: (1) for a given number of generations the population is less; (2) for the same population, more generations are required, thus producing a greater spread to the right; (3) there is a very gradual shift of the peak of distribution to the right, that is, towards higher resistance

The magnitude of these effects will depend on how close the resistance of the parent cell is to the 'bar' of drug concentration

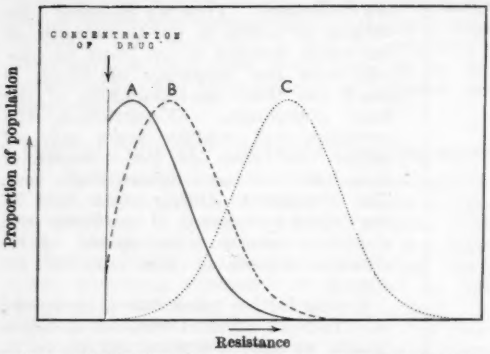

Fig. 4. Distribution of resistance for populations of bacteria grown in presence of *moderate* concentrations of drug. *A*, after a short period of growth; *B*, after a few sub-cultures; *C*, after many sub-cultures

Even the slight shift to the right in the first culture, however, will mean that an inoculum from it will contain cells of higher resistance than an inoculum from the original culture. These cells from the culture grown in drug will therefore grow in higher concentrations of drug. The culture has thus been 'trained'.

Growth in these higher concentrations of drug may perhaps give the same sort of effect as the first concentration used, and a further shift to the right may occur. With some organisms, trained to some drugs, it may be possible to repeat the process a number of times, and produce progressive 'training'.

Sooner or later a limit will be reached, beyond which 'training' cannot be induced. This represents the limit of possible clonal variation, the maximal degree of resistance possible for cells of the given strain in the given drug.

Here a new situation arises. Growth in the highest possible concentrations of drug will be limited on two sides. As well as the 'bar' to the left of the resistance curve, representing the concentration of drug, there will be a 'bar' to the right, representing the maximal possible resistance. Since cells which have maximal resistance cannot on division give cells of higher resistance, we may assume that they give either two cells of maximal resistance or one with maximal resistance and one with slightly lower resistance. In either event, there will be a tendency for cultures repeatedly grown in maximal concentrations of drug to give an increasing proportion of cells with maximal resistance, and a decreasing proportion of other cells. It can be shown that the distribution curves of cells grown in the highest concentrations of drug will have the forms shown in Fig. 5.

Basis of the New Theory

The theory rests on the assumption that a bacterial cell might divide asymmetrically in respect of drug resistance, giving one daughter cell with less and one with more resistance than the parent cell. This is not a difficult assumption to make. It is indeed more difficult to imagine that the material upon which resistance depends, probably a system of enzymes, is always and inevitably distributed in exactly equal amounts between the two cells arising from division.

It is known that the cells of a pure culture of bacteria do not show identical resistance to a drug. All workers in this field are familiar with survivor curves in which are represented the number of cells surviving with increasing concentrations of drug. Such a curve could readily be reconstructed in the form of a distribution curve, in which would be plotted the number of cells killed rather than the number of cells surviving at each concentration of drug. We have moreover shown, in confirmation of Hughes[11], that single cells of an original culture may give populations having slightly but measurably different survivor curves. This supports the view that these single cells themselves had different degrees of resistance.

Interpretation of Essential Features according to the New Theory

Let us now see how this hypothesis would explain the features of acquired drug resistance which were discussed earlier.

(1) *Graded resistance.* That resistance can be induced in a culture to a predetermined level, by growing the organisms in a predetermined concentration of drug, follows directly from the conception of a continuously graded resistance arising by unequal distribution at cell division.

(2) *Size of inoculum.* The dependence of the concentration of drug in which a culture will grow on the size of inoculum also follows directly from the theory, since the larger the inoculum the greater the 'spread' of resistance within the cells.

(3) *Rate of growth.* When an inoculum from an untrained culture is placed in medium containing drug, there exist two factors which result in a diminished rate of growth. The first is that only the more resistant cells in the inoculum will be able to grow. If only one in a hundred cells in the inoculum can survive the concentration of drug, it will in effect increase the number of generations to reach a given number of cells by six or seven. The second factor decreasing the growth-rate of the culture is the division of those cells of the inoculum the resistance of which is only just above that for the existing concentration of drug. When these divide, they would each give, according to the model, one cell of higher resistance and one of lower resistance. The latter or one of its early progeny would not be able to divide further, so that the result of the first few divisions of cells with 'marginal' resistance would be to give a low rate of increase of cells (see Fig. 3). If the inoculum contains a high proportion of such cells,

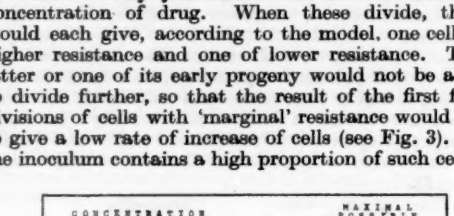

Fig. 5. Distribution of resistance for populations in bacteria grown in the presence of *high* concentrations of drug: *A*, after a short period of growth; *B*, after a few sub-cultures; *C*, after many sub-cultures

the increase in the number of cells in the culture would be smaller than in a normal culture and the *apparent* mean generation time would be increased. This point is discussed in more detail below.

As a result of these two factors, an untrained culture inoculated into medium containing drug would show a longer lag and mean generation time. If this culture is repeatedly inoculated into the same concentration of drug, there is a gradual building up of a distribution curve similar to that of the original culture, though displaced to the right. An inoculum from this will then have fewer cells which are sensitive to the concentration of drug being used, and fewer of 'marginal' resistance. Growth will therefore not be retarded so much by these two factors and 'training' will have occurred in the sense of a decrease in lag and mean generation time towards the normal.

When 'training' is complete and the organism is grown in the highest possible concentration of drug, we have the situation we described as involving the existence of two 'bars'. The distribution curve will be a narrow one, bounded on the left by the concentration of drug and on the right by the maximal possible resistance. It was suggested earlier that the latter bar might exert its effect by increasing the proportion of cells with maximal resistance. The existence of the 'bar' of drug concentration so close to that of maximal resistance must mean that cells with less than maximal resistance can very easily give rise to cells sensitive to the concentration of drug.

One would therefore expect that, for the first few sub-cultures at least, there would always be a fairly large proportion of cells which cross the 'bar' of drug concentration and do not divide further. This would mean both a prolonged lag period and an increase in apparent mean generation time. As the proportion of cells with maximal resistance increases in the cultures and in the inoculum, the lag becomes shorter and eventually normal. However, so long as a fair number of cells arise with resistance low enough to cross the 'bar', the apparent mean generation time continues to be abnormally high. Whether the mean generation time ever becomes normal will depend on the relationship between the spread of resistance at each cell division and the nearness of the existing drug concentration to that representing maximal resistance. For example, the mean generation time is more likely to continue to be prolonged if the cells of maximal resistance give on division cells of unequal rather than of equal resistance.

(4) *Reversion.* When training has occurred for a relatively short time, the distribution of resistance may not yet have reached its final form. It will be such that the proportion of cells with resistance less than the mode will be higher than the proportion with resistance greater than the mode. This proportion will be represented in an inoculum, so that a culture from it in the absence of drug will give a distribution curve which spreads farther to the left than to the right, and with a mode to the left of that of the distribution curve of the cells from which the inoculum has been taken. Depending on the organism, the drug and other factors, this shift to the left might be sufficient to make the culture measurably lower in resistance than that grown in the presence of drug. The culture would then have shown reversion.

We have seen that it may require many sub-cultures in the presence of drug for the change in the distribution curve to be completed. When this stage has been reached, there is only a small proportion of cells with a resistance to just the concentration of drug used. This is particularly true when high concentrations of drug are used, which we have suggested lead to a gradual accumulation of cells of the highest possible resistance.

Thus, the longer the cells are trained, the more permanent is the resistance acquired. This is in conformity with experimental findings.

Some Consequences of the New Theory

A series of experiments has been planned to test some of the possible consequences of the theory of clonal variation with selection. So far as these experiments have been carried out, we have obtained results with *Bact. coli* and proflavine which conform to theoretical predictions[12].

(1) *Differences between recently isolated and older cultures from a single cell.* The theory predicts that the 'spread' of the distribution curve of resistance in a culture derived from a single cell should reach its maximum only after several sub-cultures. The first culture from the single cell, that is, should have a narrow range of resistance and should consequently not be so easily trained. Our experiments have shown that the curve of a recently isolated culture is indeed narrow and widens during a few sub-cultures, and that it is usually not possible to train the culture, except perhaps to a slight extent, until it has been sub-cultured a few times in the absence of drug. The fact that a newly isolated culture may be incapable of being trained and thus differ qualitatively from an older culture has, so far as I know, not previously been recorded. It may obviously have led to erroneous conclusions being drawn by investigators who have examined only recently isolated cultures for their ability to acquire drug resistance.

(2) *Rate of growth in the presence of drug.* One of the reasons offered by the theory for a decreased rate of growth in the presence of drug is that organisms of resistance close to the concentration of the drug used may give rise to cells of lower resistance which will then not divide further. From the distribution curve, one can determine a concentration of drug at which a high proportion of cells would have this 'marginal' resistance. If serial dilutions of the culture are made into this concentration of drug, one should find that at first only the lower dilutions, which are likely to contain some of the rarer cells of higher resistance, will show growth. The higher dilutions are likely to contain only cells of marginal resistance, and so are likely to give a considerably reduced rate of growth. The result would be that the apparent count is at first small, say after the usual 18–24 hours; later, the apparent count would be very much greater. This difference would not occur when either somewhat lower or somewhat higher concentrations of drug are used, since the proportion of cells of this 'marginal' resistance is in these instances relatively small.

Our experimental results are in conformity with these predictions.

Discussion

The model of the method by which drug resistance may be acquired by micro-organisms has deliberately been kept as simple as possible. Nevertheless, it is suggested that the elaboration of this model in more realistic terms does not undermine its essential claim to provide a satisfactory explanation of the phenomenon.

We have seen that the assumption in the model of a fixed asymmetrical division of a cell in respect to

its resistance to a drug is in fact less likely than a variable asymmetrical division, with a decreasing probability of daughter cells arising with increasingly different resistance from that of the parent cell. From a statistical point of view, however, the simpler assumption, which lends itself more easily to the construction of the model, leads to much the same conclusions.

It has also been implied that the resistance of a cell, once it has arisen from division of a parent cell, is constant. It has, however, been suggested that resistance varies throughout the life-cycle of a cell[13]. This again would not alter in any significant way the deductions from the theory. It would, however, mean that, with a given concentration of drug, cells of 'marginal' resistance would be more likely to be affected by the drug as their resistance varied during their growth. This would have two effects. First, there would be a rather more rapid shift to the right in the distribution curves of cells grown in the presence of drug than is suggested by Figs. 3 and 4. Second, those concentrations of drug which coincide with a high proportion of cells of 'marginal' resistance would affect more cells than we have suggested, and cause an even greater effect on lag and on mean generation time.

It may be argued that the theory of clonal variation has no advantages over that of mutation, and indeed that the variations in resistance which we have described are due to mutational changes in the genetic constitution of the organism. It is true that one may take the view that the difference between these two theories is only one of terminology. But it is suggested that the insistence on the use of the term mutation to describe the continuous variations of resistance which exist in a culture distorts the meaning of this word. Mutation is normally used for describing a discrete discontinuous quantum-like change occurring in a small—usually a very small—proportion of organisms. Not only are the variations we described as clonal so small as to be capable of being regarded as continuous, but also they occur in a very large proportion of the cells. Indeed, the type of distribution of resistance occurring in a culture is such that there are almost as many cells of slightly higher or slightly lower resistance than the mode, as there are cells with modal resistance; there are altogether many more cells of resistance different from the modal than cells with modal resistance. As we have said earlier, it is most improbable that there could occur the vast number of small mutations which would account for the many degrees of resistance which cells may develop for many drugs.

There is, of course, no doubt that many of the properties of micro-organisms are genetically controlled, and that these may include the capacity to undergo variation such as enzyme adaptation and perhaps the capacity to become resistant to a drug. Nevertheless, the essential feature of reproduction in micro-organisms is that the reproductive material and the somatic material are identical. The whole of the dividing cell is represented in the two daughter cells. It is therefore quite conceivable—we have earlier said it is even quite probable—that division may not be completely symmetrical and the distribution of material from the parent cell to the daughter cells not exactly equal. In so far as this material includes the enzymatic systems or other mechanisms which constitute drug resistance, the daughter cells may therefore have a somewhat different resistance from that of the parent cell.

Finally, it should be reiterated that the hypothesis of clonal variation with selection does not imply that mutation or direct induction do not play a part in producing variations in cultures grown in specific chemical or other environments. It is suggested only that this mechanism might more readily explain some of the examples of acquired drug resistance. It is tempting to suppose that the easily induced changes in bacteria and especially viruses grown in specific hosts or specific tissues are also brought about by clonal variation with selection; but it remains to be seen whether the same mechanisms underlie these and other examples of induced variation.

I am grateful to Dr. S. E. Jacobs and Dr. J. Mandelstam for much helpful discussion during the formulation of the views here set out, and to Miss Joan Fleming for technical assistance in the experiments. I am especially indebted to Mr. L. Bihaly, who has given me invaluable help in the statistical aspects of this work and without whose constant advice and criticism this paper could not have been written.

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NEW FELLOWS OF THE ROYAL SOCIETY

At the meeting of the Royal Society on March 19, the following were elected to fellowship:

Dr. J. S. Anderson, deputy chief scientific officer, Atomic Energy Research Establishment, Harwell, distinguished for his contributions to inorganic chemistry, particularly in connexion with the chemistry of the metal carbonyls, complex salts, and non-stoichiometric compounds.

Dr. Kenneth Bailey, assistant director of research in the Department of Biochemistry and Fellow of Trinity College, Cambridge, distinguished for his biochemical researches on the proteins of muscle.

Prof. H. Barcroft, professor of physiology, Sherrington School of Physiology, St. Thomas's Hospital, London, S.E.1, distinguished for investigations respecting the blood supply to human muscles.

Dr. J. Barker, reader in plant physiology, University of Cambridge, distinguished for investigations on the carbohydrate metabolism of plant storage tissues.

Dr. J. C. Burkill, university lecturer in mathematics, University of Cambridge, distinguished for his researches in analysis, especially in the theory of integration, also for his contributions to the theory of trigonometrical series.

Dr. J. W. Cornforth, research chemist, National Institute for Medical Research, distinguished for his fundamental contributions to the chemistry of penicillin and its degradation products and to the chemistry of the oxazole group, and for the total synthesis of the androgenic hormones.

Dr. S. C. Curran, senior lecturer, Department of Natural Philosophy, University of Glasgow, distinguished for his contributions to electronic counting techniques, and for his researches upon the emission of β- and γ-rays by atomic nuclei.

C. S. Elton, director of the Bureau of Animal Population, Oxford, distinguished for his pioneer work in the field of animal ecology as founder of the Bureau of Animal Population and of the *Journal of Animal Ecology*.

Dr. O. H. Frankel, chief of the Division of Plant Industry, Commonwealth Scientific and Industrial Research Organization, Australia, distinguished for his combined genetical and cytological studies on economic plants.

Dr. E. F. Gale, reader in chemical microbiology, University of Cambridge, distinguished especially for his work on the amino-acid metabolism of bacteria and the effect thereon of penicillin and other chemotherapeutic agents.

Dr. A. G. Gaydon, Warren Research Fellow of the Royal Society, Imperial College of Science and Technology, London, distinguished for his researches on the spectra of flames, which have gone far in elucidating the mechanism of flame reactions under the most varied conditions.

Dr. A. A. Hall, director of the Royal Aircraft Establishment, Farnborough, distinguished for his contributions to the theory and design of aircraft and their equipment.

Prof. G. W. Harris, Fitzmary professor of physiology, Institute of Psychiatry, University of London, distinguished for his contributions to the physiology of the hypothalamus and pituitary body.

Sir Claude Inglis, director of hydraulics research, Department of Scientific and Industrial Research, distinguished for his pioneer work in studying hydraulics by the use of scale models, and for the application of these techniques to hydraulic problems in India.

Prof. Willis Jackson, professor of electrical engineering, Imperial College of Science and Technology, London, distinguished for his studies of the electrical behaviour of dielectrics and of the performance of transmission lines and wave-guides.

Prof. M. J. Lighthill, Beyer professor of applied mathematics, University of Manchester, distinguished for his researches in fluid dynamics, especially in non-linear problems of compressible flow, in supersonic boundary layer theory and in shock wave theory.

Dr. G. H. Mitchell, a principal scientific officer, Geological Survey of Great Britain, distinguished for his researches in palæozoic stratigraphy.

Prof. L. S. Penrose, Galton professor of eugenics, University of London, distinguished especially for his study of the factors responsible for mental deficiency and for inheritance studies in man.

A. R. Powell, research manager, Johnson Matthey and Co., Ltd., distinguished for his contribution to analytical chemistry and the chemistry and metallurgy of the rarer metals, which has led to important developments in methods for the extraction of platinum ores and the production of very pure metals.

Dr. H. M. Powell, reader in chemical crystallography, University of Oxford, distinguished for his elucidation of problems of chemical constitution by X-ray methods, especially of organo-metallic and clathrate compounds.

Lord Rothschild, assistant director of research in the Department of Zoology, University of Cambridge, distinguished for his investigations into the process of fertilization and the physiology of reproduction.

Dr. D. Shoenberg, reader in physics, University of Cambridge, distinguished for his researches in the field of low temperatures, especially upon superconductivity and the magnetic properties of metals.

Prof. T. Wallace, professor of horticultural chemistry, University of Bristol, and director of the Horticultural Research Station, Long Ashton, distinguished for his studies of mineral nutrition of horticultural crops especially in respect to diagnosis of deficiencies.

Prof. D. Whitteridge, professor of physiology, University of Edinburgh, distinguished especially for his studies of the nerves of thoracic viscera and of the external muscles of the eye.

Dr. R. van der R. Woolley, director of the Commonwealth Observatory, Australia, distinguished for his work on the formation of absorption lines and on convective processes in the solar atmosphere.

NEWS and VIEWS

Elihu Thomson (1853–1937)

Born in Manchester a century ago, on March 29, 1853, the son of a skilled mechanic, Elihu Thomson, pioneer in the practical applications of electricity, emigrated with his family to the United States at the age of five. After finishing his education at the Central High School, Philadelphia, he was appointed professor of mechanics and chemistry at that institution in 1876. Four years later he became chief electrician to the American Electric Company, and with Edward J. Houston founded the Thomson–Houston Company at Lynn, Massachusetts. By its merger with the Edison General Electric Company in 1892, the General Electric Company of America was formed—the largest manufacturing company of electric equipment in the world, which was to operate more than six hundred patents connected with Thomson's inventions. As director of the firm's research laboratories, Thomson discovered that the resistance of the electric arc is inversely proportional to the current passing through it, constructed the first arc-light dynamo with an automatic regulator, and was the first to use a magnetic field to move an electric arc—the principle on which magnetic blow-out switches operate. He also invented the incandescent method of electric welding, the electric watt-hour meter, and a system of colour photography. His name is given to the repulsion of a metal ring from the poles of an alternating-field electromagnet. Radiology owes to his ingenuity the first stereoscopic X-ray pictures. Thomson received medals from most of the learned societies of the world: the Rumford

Medal of the American Academy of Arts and Sciences in 1902, the Hughes Medal of the Royal Society in 1916, the Kelvin Medal of British engineering institutions in 1924, the Franklin Medal of the Franklin Institute in 1925, and the Faraday Medal of the Institution of Electrical Engineers in 1927. He died on March 13, 1937.

Sir Isaac Bayley Balfour (1853–1922)

One of the greatest botanists of his day, Isaac Bayley Balfour was born in Edinburgh a century ago, on March 31, 1853, the second son of John Hutton Balfour. Educated at the Edinburgh Academy and University, he graduated B.Sc. in 1873, D.Sc. in 1875, M.B. in 1877, and M.D. in 1883. His medical training was interrupted by his appointment in 1874 as botanist to the Royal Society's expedition to Rodriguez Island to observe the transit of Venus, and by a visit five years later to the oceanic island of Socotra to collect plants. After studying with Julius von Sachs at Würzburg and with Anton de Bary at Strassburg, he was appointed professor of botany in the University of Glasgow in 1879, and in 1884 Sherardian professor of botany at Oxford. In 1888 he was called to Edinburgh to fill the three posts which his father, 'Woody Fibre', had held—professor of botany in the University, keeper of the Royal Botanic Garden, and Queen's botanist in Scotland—and by a remarkable coincidence he occupied these positions for the same length of time as his father had done, namely, thirty-four years. In each of the universities which he served he was destined to find a department sadly in need of reorganization. At Glasgow he introduced the practical laboratory teaching initiated by his father at Edinburgh a generation earlier. He made Edinburgh an important horticultural centre. No man knew Scotland botanically as well as he did. His most substantial published work, "Botany of Socotra" (1888), includes descriptions of some three hundred new species found in that island. While at Oxford, he persuaded the Clarendon Press to publish the *Annals of Botany* and also a series of translations of foreign botanical works, under his editorship. Recipient of many honours, he was elected Fellow of the Royal Society in 1884, received the Linnean Medal in 1919, and was created K.B.E. in 1920. He died at Haslemere on November 30, 1922.

Adult Education at Leeds : Dr. S. G. Raybould

A new chair, that of adult education, has been instituted in the University of Leeds, and Dr. S. G. Raybould, at present head of the Department of Adult Education and Extra-Mural Studies and director of extra-mural studies in the University, has been appointed to fill it, with effect from October 1 next. Dr. Raybould graduated from the University of London in 1933, taking his Ph.D. in 1951, and until the end of 1935 was engaged in teaching in schools and part-time work in adult education. He then obtained an appointment in the University of Leeds as staff tutor, and in 1946 was promoted to be director of extra-mural studies, becoming head of the Adult Education Department five years later. He is at present a member of the Joint Advisory Council of the B.B.C. and of the Central Advisory Council for Education (England), as well as being vice-president of the Workers' Educational Association and deputy chairman of the Central Committee for Adult Education in H.M. Forces. Dr. Raybould's publications include a book on "The English Universities and Adult Education", a Unesco publication, and a number of articles on education.

British Steel Castings Research Association

A new research association has been recently formed in place of the Research and Development Division of the British Steel Founders' Association, and it will be known as the British Steel Castings Research Association. Mr. J. F. B. Jackson, who, as director of research to the British Steel Founders' Association, has had the responsibility for organizing and building up its Research and Development Division since its formation in 1949, has been appointed director of the new Association. The chairman of council is Mr. F. N. Lloyd, and Mr. R. Barber is the secretary. Being derived from an organization that is already three years old and has an active programme of research in hand, the new Association starts off on a good footing. Besides the investigations being carried out at its own research station, work is being done in conjunction with the many well-equipped research laboratories and plant of industrial concerns, and it is also being sponsored in the universities. Thus during the past three years research has ranged over a wide field of steel-casting science and foundry technology, and has included an important series of projects relating to industrial health and to foundry dust suppression; in this latter connexion, work at the Dust Research Station in Sheffield, which has been in operation since mid-1951, is of particular importance. At the University of Durham and at the Imperial College of Science and Technology, London, essential basic results relating to the mechanism of the freezing of steel in refractory moulds are being obtained, and at the University of Cambridge work on the metal penetration problem and towards the improvement of surface finish in steel castings has continued since 1950. Thus, in general, the formation of this new Research Association represents an important development for a country which is renowned for its steel-making, and we may expect results which will be of vital use to the engineering industry as a whole.

Transliteration of Cyrillic Script

The policy of *laissez faire* in the transliteration of Cyrillic script leads to the same name being spelt *Yachevskii* and *Jačevskij* and *Yachewsky*. This sort of thing obviously causes confusion in bibliographies, and the Royal Society has done a good service by publishing a pamphlet on "The Transliteration of Russian, Serbian and Bulgarian for Bibliographical Purposes" (from the Royal Society, Burlington House, Piccadilly, London, W.1; pp. 16; 1*s*.). The pamphlet contains tables with the recommended transliteration of Cyrillic to English and English to Cyrillic. The recommendations are agreed by the British Academy and the Royal Society and they are carefully annotated. The only disappointment (and it is an inevitable one) is that the alphabet used in English-speaking countries is not flexible enough to imitate all the sounds of the Cyrillic alphabets; and so we have to fall back on ě, š, i, ı, and so on. One hopes that other countries which use the same alphabet as in English will adopt the recommendations.

Harwell Isotope School

Owing to the continually growing use of radioactive isotopes throughout the world—British sales

abroad are now at the rate of four thousand consignments a year—the Isotope School at Harwell has had to introduce an additional course this year. The School was started at the Atomic Energy Research Establishment two years ago to teach the techniques of using and handling radioactive materials to scientists, medical men and industrial research workers. There has been such a heavy demand for places that an extra course will be held during July 6–31. Applications to be considered for this course should be sent to the Isotope School, A.E.R.E., Harwell, Berkshire, not later than June 8. Lectures and instruction at this School are given by members of the Atomic Energy Research Establishment staff. The school building, which is equipped with the latest apparatus, is just outside the security fence at Harwell. Students pay a fee of £40 for the course, and accommodation may be arranged for them, at an additional charge of £7 7*s*. a week, in a senior staff hostel near Faringdon.

Decennial Supplement for 1931 for the Census of England and Wales

THE Registrar General has recently published Part 3 of the "Decennial Supplement for 1931" (pp. 574. London: H.M.S.O., 1952; 70*s*. net). The tabulations for this volume were completed before the Second World War, but publication had to be postponed. The volume contains the aggregation of vital statistics (estimates of population, statistics of marriages, and births and deaths) for England and Wales during the period 1921–30. Most of the figures have already been published in the *Statistical Review*; but there are some tabulations of the less common causes of death for which annual figures are not sufficiently stable. For economy reasons no further volumes will be issued in this series.

The Night Sky in April

NEW moon occurs on April 13d. 20h. 09m., U.T., and full moon on April 29d. 04h. 20m. The following conjunctions with the moon take place: April 1d. 01h., Saturn 8° N.; April 12d. 02h., Mercury 6° S.; April 15d. 16h., Mars 5° S.; April 16d. 02h., Jupiter 6° S.; April 28d. 04h., Saturn 8° N. In addition to these conjunctions with the moon, Mars is in conjunction with Jupiter on April 27d. 16h., Mars 1·1° N., and Mercury is in conjunction with Venus on April 27d. 21h., Mercury 7·2° S. Mercury is too close to the sun during April for favourable observation. On April 1 Venus sets at 20h. 40m. and is conspicuous in the western sky; it becomes a morning star after inferior conjunction on April 13, but is too close to the sun to be easily observed until near the end of the month, when it rises an hour before sunrise. Throughout April Mars sets at about 21h. and is visible for some time after sunset; towards the middle of the month it lies a little south of δ Arietis, and at the end of the month is about 4° south of the Pleiades. Jupiter sets at 22h. 10m., 21h. 35m. and 20h. 55m. on April 1, 15 and 30, respectively; it lies fairly close to Mars during the month and, as is mentioned above, there is a conjunction between the planets on April 27. Saturn rises at 19h. 35m., 18h. 30m. and 17h. 25m. at the beginning, middle and end of the month, respectively, and can be seen until the morning hours; the planet is in opposition on April 14, and throughout the month lies a little north of Spica. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: April 24d. 20h. 13·6m., p^4 Leon. (*D*); April 26d. 21h. 18·2m., q Virg. (*D*); April 30d. 23h. 58·0m., π Scor. (*D*); *D* refers to disappearance. The Lyrids meteor shower will attain a maximum about April 21.

Announcements

THE Council of the Linnean Society of London has awarded the Linnean Medal for 1953 to Prof. P. A. Buxton, director of the Department of Entomology, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.

THE title of reader in plant biochemistry in the University of Birmingham has been conferred on Dr. F. W. Norris, lecturer in the Department of Applied Biochemistry.

THE following appointments have been made in the University of Leeds: Dr. (Mrs.) Edith Robinson, lecturer in the Department of Botany; Dr. G. Dixon-Lewis, research chemist in the Department of Coal Gas and Fuel Industries. Dr. R. Brown, reader in plant physiology in the Department of Botany, has resigned his post.

MR. G. R. H. NUGENT, Parliamentary Secretary to the Ministry of Agriculture and Fisheries, will inaugurate open days at the Electrical Research Association's Field Station at Shinfield on May 4. The Station will be open to members of the Association and other invited guests during May 6–8. Opportunity will be given of seeing work sponsored by the Association at the Poultry Research Department of the University of Reading and other adjoining stations.

THE regional weather services of the Western German Republic have been grouped into a central organization, to be known as the "Deutscher Wetterdienst", with Dr. Rudolf Benkendorff as director. The address of the headquarters of the organization is Bockenheimer Landstrasse 55, Frankfurt am Main.

THE Cecil Peace Prize of the Association of Universities of the British Commonwealth has been awarded for 1952 to K. H. Dawson, of the London School of Economics (at present at the Graduate School, Princeton University). The subject for the competition for 1953 is "Has the United Nations Organization been successful in carrying out the objects for which it was formed as defined in the Preamble and Chapter 1 of the Charter? Do you recommend any, and if so, what amendments in the terms of the Charter?" Essays must be sent before November 1 to the Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1, from whom further details can be obtained.

THE Association of Agriculture, the Institute of Rural Life at Home and Overseas, and Seale-Hayne Agricultural College are organizing a course on "The Countryside—a Medium for Teaching", to be held at Seale-Hayne Agricultural College, Newton Abbot, Devon, during April 8–13. The course, which is designed to impart to teachers and other interested persons a better knowledge and enjoyment of the countryside, is residential and costs £5 10*s*. inclusive. Application forms and further information can be obtained from the General Secretary, Association of Agriculture, 238–240 Abbey House, 2 Victoria Street, London, S.W.1.

THE DEPARTMENT OF PHYSIOLOGY, UNIVERSITY COLLEGE OF THE WEST INDIES

By Prof. I. F. S. MACKAY, Dr. S. J. PATRICK and Dr. P. C. FENG

THE University College of the West Indies was founded as the result of a Commission on Higher Education in the Colonies. The West Indies Committee of this Commission published a report in June 1945 and it was on the basis of this that the University College of the West Indies was planned.

For the first time in the British Caribbean, in October 1949, medical students were accepted for physiological studies. The Department of Physiology was then housed in temporary wooden buildings, where it remained until March 1952, when all the divisions of the Department were moved into new buildings. The new buildings are well lighted and ventilated and, although of simple construction, comfortable and adequate for research and teaching (Fig. 1). The detailed interior planning of the buildings and the design of the furniture and fixtures were carried out by the staff. The University has a magnificent setting of 700 acres in a valley surrounded by delightful mountain scenery.

The Department has three divisions: physiology (Prof. I. F. S. Mackay), pharmacology (Dr. P. C. Feng, lecturer in charge) and biochemistry (Dr. S. J. Patrick, senior lecturer in charge). There is a close integration both in teaching and research. The facilities of the Department, such as the animal house and workshop, are available for the three divisions. Fig. 2 shows the layout of the buildings. There is a block set aside for physiology with an extension for pharmacology, and a separate block for biochemistry. The animal house is separated from the main buildings. The lecture theatre shown in the plan is shared by the other science departments of the College, which adjoin the physiology buildings.

The Physiology Division contains a laboratory with adequate facilities for teaching forty medical students and is used both for physiology and pharmacology teaching. The usual services are provided. Each pair of students is allocated a space on the bench, which is furnished with a set of outlets for A.C., D.C., 'time', and taps for compressed air and gas (propane). There are two main research laboratories, one especially equipped for human work and one for animal work. All the necessary electrical supplies and compressed air are laid on throughout the whole Department. The extension for pharmacology houses an office and a research laboratory. There is a special dark room set aside for optical registration as well as a photographic dark room. In addition, there are the usual offices for staff which in themselves are equipped as small laboratories. The workshop is equipped to make the usual physiological equipment. The animal house, besides housing dogs and small animals, has a special research laboratory equipped for animal surgery.

The Biochemistry Division houses the departmental seminar room, which is adequate for the teaching of forty students and contains the usual projection equipment and will contain the departmental library. In this building is situated a glass and chemical store. Research facilities are provided in three main laboratories and there is a teaching laboratory to accommodate forty students.

Students are prepared for the degrees of the University of London on a "special relationship scheme". The course follows the requirements of the University of London, but as a period of six terms of study has been adhered to instead of the usual five, it has been possible to organize a more extensive practical course. The emphasis of teaching in the practical classes has been on the human aspects of physiology and biochemistry. The basic pharmacology is taught with animal experiments. The teaching of the three divisions of the Department is closely integrated, and a tutorial system where students are divided into groups of four or five is in operation. Each term these groups are re-allocated to different teachers in the Department. As the number of students in each year is small (approximately twenty) it has been possible to maintain close individual contact and supervision of their work. Science students have not yet been accepted; but teaching for applied pharmacology has already commenced.

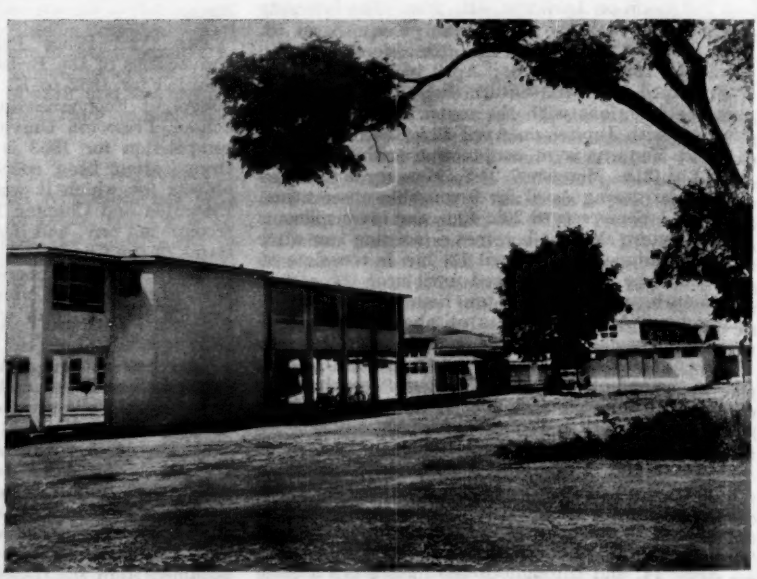

Fig. 1. Foreground left, part of the Biochemistry Division; middle distance right, part of the Physiology Division

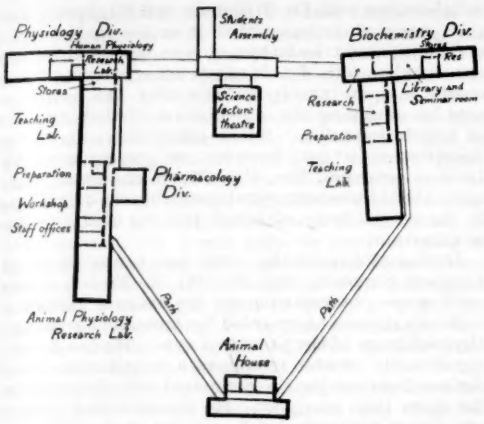

Fig. 2

The teaching of applied physiology will be undertaken when the staffing establishment has been completed.

Because of the location of the new Department in the Caribbean, it was natural that the research interests of its staff would develop in a direction where these territories offer special opportunities. Thus the over-all plan in departmental research has tended largely towards nutritional studies. Several members of the staff, in co-operation with a group from the Department of Pædiatrics from the University of Pennsylvania, are carrying out a basic nutritional survey on children and studying factors influencing nutritional status. We are pleased to report very generous assistance from the American Cyanamid Corporation, Merck and Co. and the Medical Research Council. The nutritional studies have meant an extension of the activities of the Department into relatively inaccessible parts of the island, where villages and communities are only reached after covering long distances, bad roads and surmounting such obstacles as mountain streams, etc. Those of us who have spent most of our time working in the laboratory find this field-work an interesting change. This work has provided material for biochemical studies involving an examination of the metabolism of vitamin B_{12} and a study of the relationship between various enzyme systems and malnutrition. A member of the staff seconded by the Medical Research Council has been studying the intracellular enzymes of the liver and their relation to nutritional deficiencies. Another member of the staff with biochemical interests is now studying the metabolism of the coral reef and carrying out a survey of the zooplankton distribution in these tropical waters.

Jamaica is well supplied with material for the pharmacological and toxicological studies of natural products. Some work has been done on the pharmacological principles in the 'parotid' glands of the local toad (*Bufo marinus*). Studies have also been carried out on the toxicological principles of a local fruit called the ackee (*Blighia sapida*), which is a very common item in the Jamaican diet, and is supposed to be responsible for a seasonal disease called 'vomiting sickness'. This problem is under investigation with the financial assistance of the Government of Jamaica and in co-ordination with other Departments in the University. Apart from these 'Caribbean' interests, work is continuing on more fundamental physiological problems such as cardiovascular, endocrinological and intra-cellular enzyme studies. One of the pleasing factors of the University College as a whole has been the intimate and close co-operation that exists between the new Department of Physiology and those of other science and medical departments.

All the members of staff live in a housing community close to the laboratories, and a very valuable form of social life has developed in which the staff of the Department meet one evening a week on one another's verandas to read journals and discuss their current research problems. To this club are invited members from other departments with similar interests and any scientists visiting Jamaica.

In its short history the Department has been through fire and water. About sixteen months ago a fire destroyed the temporary animal house. Fortunately nuclei of the various imported animal colonies were saved and in the new permanent buildings we are returning to normal. Very anxious moments arose when flames were sufficiently close to the temporary biochemistry laboratories to cause charring of the external walls. Valuable equipment was moved to a safe distance by many willing hands. Our passage through water occurred one night when 25 in. of rain were blown horizontally by a hurricane through the laboratories. Although the roof of the biochemistry building was torn off, the damage to equipment was surprisingly small and was soon made good.

THE THYROID GLAND

THE Society for Endocrinology and the Endocrinological Section of the Royal Society of Medicine held a joint symposium on "The Thyroid Gland" in London at the Royal Society of Medicine on February 25. This was well attended and covered a wide range of interests. Among the distinguished foreign visitors were Prof. Jean Roche and colleagues from the Collège de France, Paris.

The morning session was opened by the chairman, Sir Charles Harington, who gave a brief review on the development of thyroid research during the past twenty-five years. He recognized a chemical period dating from the characterization of thyroxine, which was followed by a more biological approach resulting from work on the anterior pituitary and its thyrotropic hormone. He referred briefly to recent work on the nature of the thyroid hormone and its biosynthesis. This has depended on the skilful application of chromatography and auto-radiography, particularly by Leblond, Gross, Pitt Rivers and the French team under Prof. Roche. He also dealt briefly with anti-thyroid substances. Although the goitrogens represent at present the only successful therapeutic application in this field, the theoretical importance of thyroxine analogues was mentioned.

Prof. Roche then described in some detail work carried out in collaboration with S. Lissitzky and R. Michel on the mechanisms involved in the biosynthesis of the thyroid hormone. The view was expressed that the iodination of tyrosine occurs after the incorporation of iodine in the thyroglobulin molecule. The circulating blood contains mainly thyroxine with small amounts of L-triiodothyronine; the absence of mono- and di-iodotyrosine, which occur only in the thyroid, was explained by the operation of a dehalo-

genase in the gland. Thyroxine is probably converted to triiodothyronine mainly in the peripheral tissues. However, the relative scarcity of triiodothyronine in the blood might also be accounted for by its more rapid excretion.

Mrs. R. Pitt Rivers outlined briefly the methods which she has recently used in collaboration with Dr. J. Gross in the identification of triiodothyronine as a significant part of the thyroid secretion. She then dealt in detail with the physiological activity of triiodothyronine, which possesses all the actions of thyroxine but appears to be about five times as active on a molar weight basis. The same ratio is obtained by different methods of assay such as goitre prevention in rats, the growth-rate of thyroidectomized rats and the minimum dose required for the control of symptoms in patients with myxœdema. The D-isomer of triiodothyronine is, however, almost inactive. Mrs. Pitt Rivers felt that L-triiodothyronine is the substance responsible for the peripheral actions of the thyroid hormone. In the discussion, Dr. G. H. Deltour reported similar results on twelve patients with myxœdema treated with triiodothyronine, and Dr. J. C. Gilliland said that triiodothyronine is more effective than thyroxine in depressing thyrotropic hormone output in the chick. Dr. S. J. Folley, on the other hand, said that he has failed to find any influence of triiodothyronine on the milk yield of cows whereas thyroxine is effective in this connexion. In reply to Mrs. Pitt Rivers, he agreed that the more rapid excretion of triiodothyronine might be of importance here.

The occurrence of post-operative myxœdema in a group of 570 patients, followed over a three-year period, has been studied by Dr. Raymond Greene. The results have been correlated with the histological appearance of the glands, and a strong correlation appears to exist between the presence of lymphoid nodules and the subsequent development of myxœdema. He said that he has formed the opinion that in the absence of lymphoid nodules no ordinary sub-total thyroidectomy will produce myxœdema, and that this complication depends almost entirely upon the state of the gland before operation. The series includes a substantial number of cases of Hashimoto's disease, but even excluding these the relationship still holds. In the discussion Prof. J. M. Yoffey stressed the possible influence of the adrenals in relation to lymphoid hyperplasia.

Mr. S. L. Hignett described a syndrome in cows consisting of thyroid enlargement and a tendency of masculinization as shown by the development of the neck muscles and the attitude of the tail. This is associated with diminished fertility and appears to present a certain analogy with the adreno-genital syndrome in man.

The last speaker in the morning session, Prof. N. F. Maclagan, gave a short account of recent work on the anti-thyroxine compounds. Most of these compounds are iodinated phenols resembling portions of the thyroxine molecule, and have aroused interest since 1946, when Woolley showed that the effects of thyroxine on tadpole metamorphosis could be antagonized by compounds of this type. The most active compound synthesized in his department was *n*-butyl 4-hydroxy-3 : 5-diiodobenzoate. This is an effective thyroxine antagonist in animals and has been tried clinically in association with Dr. Russell Fraser. It cannot, however, be administered to patients in dosages high enough to produce unequivocal anti-thyroxine effects. Results obtained in collaboration with Dr. Wilkinson and Mr. Sprott were then reported, showing that it augments the metabolic action of triiodothyronine in mice and inhibits the deiodination of L-diiodotyrosine in rats. These results support the hypothesis that the compound acts by inhibiting the deiodination of thyroxine and of triiodothyronine. Exact information about this deiodination is not, however, at present available. In the discussion, Mrs. Pitt Rivers and Prof. Roche agreed that these compounds probably are deiodinated in the animal body, although the site of this process is uncertain.

In the afternoon the chair was taken by Dr. S. Leonard Simpson, and Dr. W. R. Trotter opened with some observations on the natural history of Graves's disease as revealed by treatment with antithyroid drugs of the thiouracil type. He has found a significantly greater relapse-rate in patients treated for less than one year as compared with those treated for more than one year. He thought that patients who have relatively brief episodes of thyrotoxicosis are particularly liable to have one or more subsequent episodes. A further study of the patients has shown that relapses under treatment are significantly more frequent in winter and spring than at other seasons in the year. The factors concerned in this seasonal relationship are obscure, and Dr. Trotter is not impressed with the influence of psychological stress. In the discussion the influence of hot weather and of sunburn were mentioned; but no clue to this seasonal variation was forthcoming.

The next paper, on thyroid activity in the rabbit, by G. W. Harris, C. von Euler, J. Brown-Grant and S. Reichlin, was read by Prof. Harris. He described a technique employing iodine-131 which he thought gives a measure of the output of hormone by the gland over a period of some weeks. The exposure to cold and administration of thyrotropic hormone increase the rate of output, whereas confinement in the dark, thyroxine, and adrenocorticotropic hormone diminish the rate of output. This hormone is thought to produce its effect via the output of the thyrotropic hormone by the pituitary. In the discussion Dr. Russell Fraser directed attention to the need for a further analysis of emotional factors. He thought that, while fear does not cause thyroid stimulation, other emotional stimuli may do so. Dr. M. Reiss described the inhibitory effect of adrenalin on thyroid function, and Dr. Trotter expressed some doubts as to the interpretation of the release curves shown.

Dr. A. Stuart Mason reviewed methods for assaying the thyroid-stimulating hormone and presented some results on uptake of phosphorus-32 by the thyroid. He thought that this method is complementary to those involving iodine-131, as it is dependent upon hyperplasia rather than hyperfunction. Experiments with iodide suggest that its effect is produced by inhibiting pituitary secretion of thyroid-stimulating hormone rather than by action on the thyroid gland. Prof. Roche expressed his interest in the method and speculated upon its possible relation to mechanisms involving energy-rich phosphate bonds and the biosynthesis of thyroglobulin.

Dr. Russell Fraser spoke of the need for laboratory tests for thyrotoxicosis. While the diagnosis is obvious in perhaps 30 per cent of cases, more frequently it is to some extent a matter of opinion, and objective evidence of hyperfunction is of great value. He thought that measurements involving

iodine-131 probably include the best single tests at present available, and, while methods involving the output of hormone as described by Prof. Harris are useful in animals, for clinical work all successful tests depend upon uptake of iodine-131 by the gland. Fortunately the uptake is usually equal to the output in the untreated patient. The method employed at the Postgraduate Medical School of London depends upon measurement of urinary radioactivity and the calculation of a *T* factor. Dr. Fraser's results show that this test is highly efficient in the diagnosis of thyrotoxicosis. It is not quite so good in cases of doubtful myxœdema, although classical cases always give low values. After treatment with goitrogens, the intake is no longer equal to the output, and the position is complicated by iodine deficiency. The test can usefully be employed three months after therapeutic doses of iodine-131.

Results illustrating the diagnostic value of serum protein-bound iodine estimation in the diagnosis of thyroid disorders were described by Dr. R. R. de Mowbray, who said that he cannot agree with some previous claims and has found high values in only 62 per cent of patients with hyperthyroidism. In hypothyroidism, results are below normal in 85 per cent of cases. High levels are seen in normal pregnancy. The overlap with normal values is a definite limitation to the usefulness of this test, but it nevertheless has its value, particularly in the case of patients intolerant of the estimation of basal metabolic rate. Mr. A. Tickner, who joined Dr. de Mowbray in this paper, then described some of the laboratory hazards of the estimation. He also reported some results with serum cholinesterase estimation in thyrotoxicosis. Although high values are frequently obtained, the estimations are of little diagnostic value.

The chairman, Dr. Leonard Simpson, wound up the symposium with a short summary, in which he said that he was particularly impressed with the application of chromatography and the use of radio-isotopes in this field. As a clinician he thought that the relationship of the thyroid with other endocrine glands would repay much further study, and he gave a number of examples illustrating these relationships. He hoped that a later symposium might help to explore these other endocrine relationships.

METHODS OF PLANT PEST AND DISEASE ASSESSMENT

THE meeting of the Association of Applied Biologists at Imperial College, London, on February 27 was devoted to a symposium on the assessment of plant pests and diseases. In the opening paper, Mr. E. C. Large, of the Ministry of Agriculture's Plant Pathology Laboratory at Harpenden, referred to the wealth of information[1] on plant diseases in England and Wales that had been extracted from monthly reports sent to the Laboratory since 1917, and gave an account of some of the recent surveys, undertaken jointly by the Laboratory and the National Agricultural Advisory Service, to supplement the reporting service and obtain more quantitative information on the losses caused by plant diseases throughout the country. Mr. Large described the way in which an investigation on potato blight forecasting[2], begun in 1950 in collaboration with the Agricultural Branch of the Meteorological Office, had been developed into a comprehensive survey for both outbreak dates and progress of blight. From the survey maps and curves for the progress of blight on the foliage, taken in conjunction with the results of spraying trials at key centres, it would be possible within a few years to give reliable estimates of the mean gain, or loss, to be expected from routine protective spraying in each region of the country[3]. Disease-assessment (or, as Mr. Large now calls them, 'plant pathometric') methods applied in potato haulm destruction trials at twelve centres over a period of three years were also clearly revealing the blight conditions under which haulm destruction was, and was not, of value for the prevention of the disease in the tubers[4]. Other investigations in progress included a survey of *Epichloe typhina* attack on cocksfoot seed crops[5], now in its third year; a survey of common scab in potatoes, begun in 1952 in collaboration with the Potato Division of the Ministry of Food; and a survey of clover rot in crops of broad red and late-flowering clover, begun in 1953.

The second paper, by Dr. H. E. Croxall (N.A.A.S. Provincial Headquarters, Newcastle upon Tyne), described joint work with D. C. Gwynne and J. E. E. Jenkins in devising rapid methods for assessing the damage caused by apple diseases, particularly apple scab (*Venturia inæqualis*) and brown rot (*Sclerotinia fructigena*). Apple scab damage on the foliage might be conveniently expressed in terms of mean percentage area of the leaves covered by lesions. This could be calculated by comparing leaf samples with standard diagrams showing the appearance of individual leaves with known percentage areas covered by scab. This method was too time-consuming for rapid survey work, and from it had been derived a word-picture key in which brief descriptions were given of the appearance of branches on which the leaves had a known amount of scab damage. In a limited number of tests this method had given results of the same order as those obtained by the standard diagram method.

Similar keys had been drawn up for assessing the amount of scab blemishes on the fruit before picking and also the loss in crop due to brown rot. The results achieved so far were reasonably in agreement with those obtained by a sampling technique using standard diagrams. The possibility of correlating the mean percentage area of fruit covered by scab lesions with the grading of fruit according to the recommended grades of the Ministry of Agriculture Marketing Division was now being investigated. Methods were also being developed for giving a direct estimate of loss of value due to scab in samples of apples after picking.

Dr. R. Hull, of the Rothamsted staff (Dunholme Field Station), dealt with the records of sugar beet diseases made each year by the agricultural staff of the British Sugar Corporation under a scheme organized at Dunholme. Counts of virus yellows in sample fields were checked against yearly estimates of the acreage affected at the end of August. The disease had built up from low levels over four-year periods to peak infections in 1945 and 1949 when more than 50 per cent of the crop was infected. The weather in 1952 had been very favourable for aphid development and movement, and a severe attack of the disease developed late in the season. The losses caused by the disease were assessed by allocating an experimentally determined loss of 4–5 per cent of sugar yield for each week during which plants showed

symptoms until harvest. In a bad year, such as 1949, this amounted to about 20 per cent of the sugar yield, or some 900,000 tons of sugar beet. This figure was checked by calculating a regression coefficient of yield on percentage of plants with yellows for the various factory areas. Surveys were also made of the incidence of yellows in sugar beet seed crops and of aphids in clamped mangolds in spring, as these virus and aphid sources were of importance in the initiation of outbreaks of yellows in the root crop.

In opening the discussion on the plant disease assessment papers, Mr. L. P. Smith (Meteorological Office Agricultural Branch) emphasized the need to establish the relationships between the microclimate on the plant surface and the macroclimate as defined by the recording instruments of the meteorologist. Meteorological records could already be used for forecasting potato blight, since it appeared that 75 per cent relative humidity in the air was indicative of saturation on the potato leaf surface. Advances in the application of meteorology to plant disease forecasting depended on exact definition by the plant pathologist of the meteorological factors permitting infection and on the provision of accurate means of disease assessment.

Mr. W. C. Moore (director, Ministry of Agriculture Plant Pathology Laboratory), in concluding the morning session, paid tribute to the pioneer work of Mr. Buddin. He pointed out that the United Kingdom was the only country in which full-time appointments had been made for the development and co-ordination of work on pest and disease assessment. The successful prosecution of this work depended on the co-operation of all those concerned in crop protection who were willing to give time to the surveys necessary to obtain accurate information.

The afternoon session opened with a paper on field technique in pest assessment by Mr. A. H. Strickland, also of the Plant Pathology Laboratory. Mr. Strickland recorded that routine quantitative survey work was started on some twelve pest species by entomologists in the National Agricultural Advisory Service in 1946. Initially the approach had been somewhat arbitrary—necessarily so in view of the almost complete lack of information on pest population variability within and between fields or provinces.

In 1950 four seasons work on the cabbage aphid was critically reviewed and it was realized that a much more intensive approach was needed to give reliable results on aphid abundance and crop damage. Since that time, work had been directed to assessing cabbage aphid damage accurately on an experimental plot scale and in overcoming some of the difficulties met. Two examples were given of the way in which seemingly straightforward population and yield or damage data could be misinterpreted.

It had become increasingly clear that a full interpretation of results in terms of biological activity was not in general possible on present knowledge. In view of the importance of assessing the significance of major ecological factors in relation to pest population build-up, a new pest incidence report scheme had been drawn up and was being given a trial.

Mr. F. G. W. Jones (School of Agriculture, University of Cambridge) classified the seedling pests of beet into three groups: those causing loss of stand only, those causing defoliation only, and those causing both defoliation and loss of stand. Injury caused by these pests could be assessed in terms of money, yield or, occasionally, plant population.

Normally, an excess of 'seed' was sown, from which only 25 per cent of potential seedlings appeared above ground, 10 per cent having succumbed to fungal disease, 5 per cent to insect attack and 60 per cent to other causes, mainly arising from the physical properties of the soil. The cost of insecticidal seed dressings applied to beet on arable land had to be regarded as an insurance against unexpected attacks, especially where reduced seed rates were used to ease the labour problems of singling.

Field experiments had been made in which defoliation and loss of stand were produced artificially. The results of five such experiments showed clearly that beet was capable of withstanding up to 75 per cent defoliation at the four- and eight-leaf stages without suffering more than 10–15 per cent loss of yield. Re-drilling was undesirable so long as even one-half of the intended plant population remained, provided the surviving plants were fairly evenly distributed. The use of insecticides against pest attacks of moderate severity was likely to be uneconomical if the cost exceeded £3–£5 per acre.

Mr. D. W. Wright (National Vegetable Research Station, Wellesbourne) described two methods of assessing damage caused by larvæ of the cabbage root fly. The first was an estimation on the tap root of the proportion of the area injured by the larvæ; the second was by recording crop yield. These two methods showed little agreement, as the effect of a given level of root fly infestation on crop yield varied from year to year. This appeared to be correlated with the rainfall during the main period of crop growth and infestation. When the rainfall over this period was at or below average, very considerable increases in yield occurred following control of the pest. When the rainfall was well above average at this time, however, no visible or significant improvement followed control. It would thus seem that under dry soil conditions a damaged root system was unable to provide the plant with an adequate supply of water.

Losses due to this insect appeared to be greatest on crops transplanted early in the year. Crops transplanted later, and harvested in autumn and winter, were usually less affected, but with these also marked increases in yield had been obtained when the root fly was controlled.

Dr. M. Cohen (N.A.A.S., Newcastle), opening the discussion on pest assessment, stressed the need for long-term records and for relating insect attack to the physiology of the host plants. Hitherto the only records that had permitted forecasting of pest attacks had been those on leatherjacket populations. Accurate figures on losses due to pests could help to guide the intensification of control measures into those channels that would increase agricultural production most rapidly.

Prof. H. W. Miles (Wye College, University of London) considered that many lines of field work would be promoted as a result of the symposium. He directed attention to the potentialities of plants to compensate for insect injury, and pointed out that the grower must be shown by realistic figures the amount of crop loss due to pests. The need to combine economy with efficiency in pest control was specially apparent at the present time.

Dr. W. F. Jepson (Imperial College Field Station), and other speakers, referred to work on varietal susceptibility to pest damage, and pressed for a clear discrimination between degree of attack and loss of yield.

Dr. I. Thomas (Plant Pathology Laboratory, Harpenden) noted that methods of assessing plant disease loss had been initiated by research workers, but in assessing losses due to pests, methods had had to be improvised. It was essential to avoid the pitfall of ascribing losses to pests when nutrition and soil factors were primarily responsible. Dr. Thomas again stressed the need for a generous measure of co-operation and goodwill to ensure the successful development and application of methods of assessment.

R. W. MARSH

[1] Moore, W. C., *Bull. Min. Agric.*, No. 126 (1943) and No. 139 (1948), and earlier bulletins.
[2] Large, E. C., *Plant Path.*, **2**, 1, in the press (1953).
[3] Large, E. C., *Plant Path.*, **1**, 109 (1952).
[4] Large, E. C., *Plant Path.*, **1**, 2, 56 (1952).
[5] Large, E. C., *Plant Path.*, **1**, 23 (1952).

RECENT GEGENSCHEIN STUDIES IN THE SOVIET UNION

A GOOD deal of work has recently been done, in the Soviet Union, on the Gegenschein or 'counterglow', as a result of which a fairly definite point of view has developed. In particular, the Glydén–Moulton theory is regarded as quite overthrown by mathematical analysis (Moïseyev). The Seeliger reflexion theory may account for some portion of the counterglow luminescence, but not for the main effect. Taking advantage of the extraordinarily good seeing conditions in Central Asia, Soviet astronomers have shown both by visual and by photometric observation that the counterglow is variable in shape, in intensity, and in the spatial distribution of its luminescence; that it has an emission spectrum; and that it has a parallax which places it at a distance of about twenty earth radii. This has resulted in the revival of the theory of a gaseous tail extending from the earth's atmosphere. It is thought that the tail is excited to luminescence by the solar 'corpuscular radiation' at some distance from the earth, presumably after it crosses the boundary of the 'forbidden region' (of Chapman, Martyn, Alfvén).

Some of the Russian papers on this subject[1–4] have now been translated and issued in full[5]. A short account also appears in the 1952 edition of Mitra's "Upper Atmosphere"[6], which has just become available.

According to Fesenkov[2], the tenuous exterior atmosphere of the earth may have the form of a paraboloid of revolution, convex toward the sun. Nothing is said about the mechanism by which this form is maintained; but presumably it is a combination of radiation pressure, actual escape, and very high 'bounces' of colliding molecules. The density of the gas is halved every 4·7 earth radii; but apparently, in Fesenkov's view, is uniform over any cross-section of the tail (see ref. 2, p. 500). Astapovich[1], on the other hand, describes the tail as a hollow sleeve of gas, driven off from the twilight rim of the earth by radiation pressure, like the tail of a comet.

To the recognized description of the counterglow, a completely new detail has been added by Divari[3] and Fesenkov[4], who independently discovered that, as the counterglow descends to the west of the meridian, there appears a broad pyramid of fainter luminescence connecting it to the horizon. To this phenomenon Fesenkov gave the name "false zodiacal light" (see ref. 6, p. 492).

The false zodiacal light is confined to the western side of the night sky; it does not appear in the east when the counterglow is rising. No satisfactory explanation is given for this remarkable fact. Obviously it cannot be any ordinary atmospheric distortion or superimposed luminescence, at least so long as our model of the atmosphere is symmetrical. It is necessary to postulate some atmospheric asymmetry in the evening twilight zone, and if we accept the gaseous tail hypothesis at all, we are led to suspect that the asymmetry can only be the tail itself.

In a prefatory note to his translation[5], Mr. Hope has suggested (assuming the gaseous tail really to exist) that the false zodiacal light may be explained by invoking a hitherto unconsidered fact, namely, that the earth's rotation will assist the radiant pressure of the sunlight over the evening twilight zone, but will oppose it on the morning side. The result may be that the gaseous stream is driven off mainly, if not entirely, from the evening side; Astapovich's 'gaseous sleeve' is not complete. If this incomplete sleeve is itself faintly luminous (below the actual counterglow), it will be seen against the western night sky, but not in the east.

A further suggestion is made to account for the fact that the false zodiacal light does not make its appearance before about two o'clock in the morning. This suggestion involves the idea that the fainter luminescence in the incomplete sleeve is generated by atoms or molecules, excited or dissociated in the sunlight, dropping to a lower level of excitation or recombining when they pass into the terrestrial umbra high above the earth. (Incidentally, it seems that the long cone of the earth's shadow, as a possible generator of radiation in the remote exosphere, has been little considered.)

[1] Astapovich, I. S., *Priroda*, No. 1, 25 (1950).
[2] Fesenkov, V. G., *Priroda*, No. 11, 5 (1950).
[3] Divari, N. B., *Astro. Zhur. SSSR.*, **26**, No. 6, 355 (1949).
[4] Fesenkov, V. G., *Astro. Zhur. SSSR.*, **27**, No. 2, 89 (1950).
[5] Hope, E. R., 305 Wilbrod Street, Ottawa 2, Ontario.
[6] Mitra, S. K., "The Upper Atmosphere" (Calcutta, 1952).

ABSTRACTING AND LIBRARY WORK IN THE U.S.S.R.

THREE articles on the organization of scientific information and abstracting in the Soviet Union have appeared in recent issues of *Vestnik Akad. Nauk SSSR* (**22** (8, 9), 41, 46 and 80; 1952). The first of these is by A. V. Kremenetskaya and E. V. Vasilyeva, dealing specifically with abstracting (referata) and the work of the State Scientific Library. This is the largest in the Soviet Union, with about three and a half million books and other publications. Among its main objects are publicity on advanced experimental work in industry and on the achievements of Soviet science and technology, and also information on the work of other countries, especially those of Eastern Europe. Special attention is given to the provision of information in suitable form to students. In fact, the library is under the direct control of the Ministry of Higher Education; but it also has a wider range, and its services are available through two hundred and sixty industrial centres throughout the Union.

It is not clearly stated in what precise form the information is supplied—though leaflets are mentioned later—but apparently more than twelve thousand 'informations' are issued annually, manifolded and distributed to the extent of three hundred and fifty thousand copies.

Up to 1948 'subscribers' filled in questionnaires on matters in which they were interested; but this proved unsatisfactory and was replaced by subject lists and abstracts prepared by the Library. Extreme subdivision of subject-matter is not considered desirable, and many fields that were previously thus divided have now been reconsolidated. At present there are seventeen main classes in the industrial field, including nuclear physics, ultra-short-wave radio technique, tele-mechanics, etc., subdivided into more than a thousand subjects. Methods of scanning both books and journals in the library are described at some length, with special reference to the needs of technical and scientific workers, and to the relative value of so-called popular works on science and technology. 'Capitalist' publications must, of course, be carefully examined, but with a somewhat more critically selective acumen, for which various reasons are given.

More than fifty specialists are employed under an editorial staff to examine books and journals and to prepare abstracts. Nothing is said in this first article of the distinction attempted in the third article between abstracts, annotations and reviews, nor of a critical function discussed therein (see below). Up to 1941 the material collected by the Library was in the form of short 'annotations' printed on the usual library index cards, but to increase efficiency and save the time of specialists "there was a constant urge towards more detailed abstract annotations". Length of abstract naturally depended on a number of factors: material in a foreign language not readily accessible would have to be more detailed; literature from a large central publishing-house in the Soviet Union need have little more than title and date. The abstract is usually in the form of single leaflets, for which various advantages are claimed. Co-operation with other libraries and institutes, a call for suggestions and comments, and a few notes about binding, etc., conclude this first article.

The second article, by Dr. L. I. Gutenmakher, is on the mechanical aspects of information work, though it is a little indefinite. It emphasizes the rapidly accumulating and enormous dimensions of modern scientific literature, and notes the various difficult and complex problems involved.

The president of the Academy of Sciences of the U.S.S.R., A. N. Nesmeyanov, has recently suggested a study of mechanical methods for dealing with information work (*Vestnik Akad. Nauk SSSR*, 22 (2), 16; 1952), so that Stalin's doctrine—only by mechanization can Russian industry hold its place—can be applied here also. No actual machine is described; but certain general principles on which its design might be based are suggested by the author. Information in an abstract should be presented in simplest terms or elements, compressed and uniformly formulated. From one to two hundred such elements may constitute the average abstract. Analysis of material, formulation and record (abstracting) might be done through suitable rules and instructions to authors, or by special staff in one or more institutes; but the selection of information relevant to a given subject or problem should be achieved by mechanical means. Some necessary conditions are discussed, including the use of auto-cameras (photo-automatas), with examples drawn from chemical kinetics and reactions. Brief and precise systems of record are essential, with the maximum use of mathematical and other symbols and formulæ. Russian patent specifications are said to be a step in the right direction of formulation. Another problem briefly considered is that of classification, though here again the proposals are a little vague and indefinite, including a suggested use of 'addresses' and the modern technique of commutation.

The third article runs to twelve pages and deals in greater detail with abstracting (referata). The authors are K. R. Simon and G. G. Krichevskiya. The former is a well-known writer on the subject in the U.S.S.R., with numerous articles in the *Sovetskaya Bibliografiya* and other journals. A few statistics are presented to begin with. Figures for 1949 show that, in natural science, medicine and technology (engineering) only, published articles in all countries had reached 1,850,000 a year. In chemistry alone they exceeded fifty thousand a year. In the Soviet Union scientific printed publications, including books and official documents, in 1951 amounted to more than a hundred thousand. In the Russian view it is necessary to distinguish abstracts (referata) from annotations, the purpose of which is to disclose in more or less detail the subject-matter (thematics), and from reviews or criticisms. The distinctions appear a little arbitrary: it is shown later that an abstract must, of course, disclose the subject-matter, and also include a critical function.

The importance of a preliminary general survey (*obzor*) is emphasized—a summary or outline, which may also be informative or critical, although its precise nature, purpose and realization are not very clearly given. A short historical survey relates to abstracting in the Western countries (*Chem. Abst., Brit. Chem. Abst., Centralbl.*) and to the work of Unesco, with various points of criticism, such as the neglect of social sciences, absence of critical acumen, the complete omission of books from the general scope and, it is stated, neglect of material other than English, French and German; also a lot of unnecessary duplication. This matter of a critical function has been considered in some detail by K. R. Simon (*Sov. Bib.*, 1–3, 341; 1933).

A detailed account is given of Soviet progress in abstracting, starting with the decree of January 9, 1928, under which a Commission was established to look after "Indexes of Scientific Literature", including abstracts of all Soviet scientific publications. The original grandiose scheme, as the authors term it, of large annual volumes, could not be properly realized, and there were several defects. Many Soviet abstract publications are noted. The real requirements of an efficient abstract service are described in detail. For example, it must be a true organic system, established on a uniform plan, in accordance with a logical classification of the whole field of human knowledge, of which the main classes are indicated, including philosophy—an inclusion which may possibly be questioned.

For each division of knowledge the question arises as to its appropriate independent abstract medium, having regard to its various aspects, sub-divisions, rate of development, relevant literature, etc. It is clear that some of the main divisions cannot be provided for within the limits of one abstract publication—for example, in the sciences of philology and comparative literature—in view "of the brilliant

publications of I. V. Stalin in these fields". But as regards chemistry, long experience with abstract journals has convinced the authors of the paramount need for some single but authoritative and comprehensive chemical abstract journal in the U.S.S.R., for both the theoretical and practical domains.

There is only space here to indicate the other points discussed—for example, choice of material to be abstracted, which should include not only periodicals and patents but also books, etc. (even the general press and popular magazines); linguistic scope of abstracts (what countries and languages, for there are already ten different languages in the Soviet Union itself); nature and value of the information provided, with critical evaluation; what the abstract should contain; and one or two miscellaneous considerations. W. G. Cass

THE TURKISH EARTHQUAKE OF MARCH 18

THE recent earthquake in Turkey was not one of the greatest of that region, but it happened in a moderately well populated area and consequently the casualties have been relatively great.

Provisional readings of the Edinburgh east–west component seismogram indicate the initial time for the earthquake as 20 hr. 06 m. 16 s. G.M.T. The epicentre appears to have been near Çan in the province of Çanakkale, Western Anatolia (lat. 40° N., long. 27° E.), and the depth of focus normal. The Edinburgh Milne–Shaw seismograph has a magnification of 250, and the maximum surface waves, which are pronounced in this shock, measure 7·1 cm. amplitude (mean to extreme) on the record.

The earthquake was experienced chiefly in the Provinces of Çanakkale and Balikesir, bordering the Ægean Sea, and south of the Dardanelles. The area between Yenice and Gonen suffered severely. In this district more than six hundred houses were destroyed and many more were damaged; fire added to the damage. Çan is a centre of routes in the area, the railway lines from Çan going respectively south-east to Baya, north-north-east to Biga and Karabiga and west-north-west to Çanakkale. All these communications were interrupted and telephone and telegraph lines were down. Reports from fifty-seven villages in the epicentral area were still awaited two days after the earthquake. The shock was felt in Istanbul as strongly as any earthquake since 1906, and some apprehension was felt. Some buildings were damaged in Istanbul, including the Dolmabagtche Palace, where walls cracked and plaster fell off the ceiling of the famous reception hall. Damage has been reported from the Ægean Islands of Chios and Lesbos and the tremor was felt throughout northern Greece. The full list of damage and casualties cannot yet be assessed, but reported damage two days after the event is estimated at a quarter of a million pounds sterling, deaths at more than five hundred and injured at more than a thousand. Ankara observatory reported sixty-five aftershocks on March 19 and fourteen more to noon on March 20.

In Turkey there are annually some hundred to hundred and fifty earthquakes which are felt but which do no damage. Some others do damage only in the immediate vicinity of their epicentres; but since 1938, excluding the present shock, there have been thirteen disastrous earthquakes. These have been: (*a*) in Central Anatolia—Kirsehir-Yerköy, 1938 (19 Nisan 1938 Orta Anadolu yer deprenmesi. Ed. Paréjas and Hamit N. Pamir. Istanbul Üniversitesi Jeoloji Enstitüsü Neşriyati, No. 5, 1940); (*b*) in Septrionale Anatolia—Erzincan (magnitude 8), December 27, 1939 (27 Birinci Kânun 1939 Erzincan yerdepremi. Ed. Parejas, I. H. Akyol, E. Altinli. I.U.J.E.N., No. 10, 1942, also *Nature*, January 6, 1940), Erbaa-Osmancik (magnitude 7·5) 1942, Adapazari 1943, Amasya-Tosya (magnitude 7·5) 1943, Bolu-Gerede (magnitude 7·5) 1944, (*c*) in south-east Anatolia, Ceyhan-Misis 1945, Van 1945, Varto 1946, Bingöl 1949; and (*d*) in the Ægean area in which the present epicentre is situated, Dikili 1939, Ayvacik 1944 and Çesme-Karaburun 1949. In the course of these thirteen earthquakes, fifty thousand people have been killed and a hundred thousand houses destroyed or seriously damaged. Since 1938 earthquake damage has probably cost the Turkish people 100 millions of Turkish pounds.

Tectonically, the area around the Marmara basin consists of faulted synclines, and the area adjoining the Ægean Sea consists of faulted depressions. In between these synclines or depressions there are anticlines with palæozoic cores, 'plis de fond' or 'massifs'. The elements have been orogenically active throughout geological time, but since the end of the Néogène the general movement has been an upward (epirogenic) one. This rise is shown by the altitude of Néogène lacustrine deposits and by the quaternary terraces. To-day it is still continuing and is evidenced by the sudden changes of equilibrium between sections with faulted contact. Earthquakes accompany the faulting. Ernest Tillotson

THORNTHWAITE FOREST, CUMBERLAND

THORNTHWAITE was one of the first forests to be established by the Forestry Commission in Cumberland, which took over eleven hundred acres of land around the Whinlatter Pass in 1920 and began planting the same year. Other land has been added from time to time, the latest acquisition being in 1947, and, since planting has proceeded continually, all ages of trees up to thirty-two years are represented. A short record of this forest has now been published by the Forestry Commission in a booklet entitled "Britain's Forests—Thornthwaite"*. The bulk of the work on the larger sections—Whinlatter, Wythrop and Dodd—was finished by 1931, and thus most of the plantations are more than twenty years old. Formerly, the young trees for planting were raised at a small forest nursery near Thornthwaite village; but nowadays they are brought from larger nurseries near the Scottish border. The forest lies three miles from Keswick, two and a half miles from Cockermouth, and twenty-three miles from Carlisle. Its greatest length from north to south is seven miles, and its greatest breadth six miles, including outlying plantations. The distance around Bassenthwaite Lake by road, which touches on most of the plantations, is eighteen miles.

Soon after the Commission commenced planting in the beautiful Lake District, there was a considerable

* Forestry Commission. Britain's Forests—Thornthwaite. Pp. 20. (London: H.M.S.O., 1952.) 1s. net.

outcry—almost inevitable, since the objectives of forestry are little appreciated in Britain. Such forestry as existed in the country a couple of centuries ago was confined to hardwoods; for many reasons, much of the Cumberland hills were only suitable for conifers.

There are many aspects from which Thornthwaite may be examined. Perhaps one of the best known is from the south. As one approaches the well-known town of Keswick by way of the main road from Ambleside, a beautiful panorama is unfolded which includes the young forest, now covering five thousand acres. About two and a half miles short of Keswick, Bassenthwaite is seen below with the young plantations of spruce, pine and larch on the hills on either side with, at the back on the far side, Skiddaw rising to 3,053 ft.

The forest is divided into several sections bearing the local names of the areas concerned, the latest plantations dating from 1948 and 1950. The kinds of trees used are the spruces, Sitka and Norway, Scots pine, and, in small amount, *Pinus contorta* and *P. mujo*, with Douglas fir, Lawson's cypress and western red cedar. On the bottom soils and in sheltered places Japanese larch is planted. Curiously enough, the European larch does not do well in this region. More latterly, the Commission has been planting amenity belts along the Bassenthwaite roads to break the monotony of the dark conifers. The belts include the American red oak, beech, wild cherry, western red cedar, ash, birch and maple, which are seen at their best in the spring and autumn. Thinnings are being made in the older woods, from the poles of which pitprops and finer stakes are yielded, providing a return from the forest and providing work for a considerable labour force.

E. P. Stebbing

NATIONAL PARKS IN GREAT BRITAIN

THE third annual report of the National Parks Commission* covers the year ended September 30, 1952, and notes the confirmation of the Designation Orders for Snowdonia, Dartmoor and Pembrokeshire coast national parks, and the designation, on February 12, 1952, of a sixth area, the North York moors, as well as consultations with local authorities concerning a proposed Cornish National Park. It records the view that, in spite of unpropitious economic circumstances, the design of the National Parks Act is taking shape. The claim that substantial advance has been made, however, scarcely seems to be justified by the contents of the report, although it appears that, with the exception of Snowdonia, the park authorities, in spite of handicaps due to economic circumstances, have been working with some promise and that the problems of each park are being studied by each authority with a full and proper appreciation of the intentions of the National Parks Act. The tale of administrative difficulty due to ministerial faithlessness, and the persistence of misconceptions as to the effect of designation of areas as national parks on access, is repeated from the previous report; and although the references to financial difficulties are more oblique than in the second report of the Commission there is no substantial evidence in the present report of the disappearance of the parsimony which was last year reported as hindering its educational work through the distribution of the proposed leaflet on the Country Code.

Nothing is said about that leaflet in the present report, and, although the education authorities have rendered much assistance in making the Country Code widely known to the youth of the country, it may be inferred that the Commission's own proposal is still frustrated. The most hopeful features of the report are, in fact, to be found, first, in the evidence it provides of widespread co-operation and goodwill, and, second, in the determination with which the Commission has maintained its position in the face of official indifference.

On the first, directors of education, the Railway Executive, the London Transport Executive and the Central Office of Information have helped to make the Country Code widely known, while much help has been received from local authorities, the Peak Planning Board, the Youth Hostels Association, the Ramblers' Association, the County Councils of Cornwall, Devon, Dorset and Somerset, and individual ramblers at one or more of the numerous stages—from preliminary survey to the erection of cairns and stakes or the provision of hostel accommodation involved in the establishment of the projects for long-distance routes, such as the Pennine Way, now at an advanced stage, the Cornish North Coast Path, the Pembrokeshire Coastal Path, the Thames Riverside Walk, the South Downs route and the Pilgrim's Way. The extent of such co-operation fully justifies the Commission's claim that "the designation, progressively, of the finest areas of England and Wales as National Parks signifies public recognition of the supreme quality of our landscape and of its permanent importance as a factor in the moral and physical welfare of our people, and of the need on that account to ensure that it passes inviolate to future generations". Nevertheless, such public recognition is incomplete, and whether, in fact, the long-term ideal, of which the National Parks and Access to the Countryside Act is the practical expression, is to be realized depends largely on the success of the Commission's stand in regard to administration, and the extent to which the Commission is supported in a matter which, the Commission reiterates, "is of pivotal importance not only to each individual Park but to National Parks policy as a whole".

For this reason the Commission has appended to the present report details of the administrative arrangements for the Peak District, the Lake District, the Dartmoor and the Pembrokeshire Coast National Parks. Closer acquaintance with the practical problems has only confirmed the Commission in the view it has held most strongly from the start, and which has been held by all others before it who have studied this problem—namely, that, short of an organization such as was contemplated by the Hobhouse Committee, the joint planning board, with its own whole-time planning staff, is the most appropriate and serviceable administrative instrument. Such a joint planning board should have at least a whole-time planning officer, who should be a servant of the board and independent of any of the component local authorities. The Commission regards this as a corollary to the principle that a national park should be treated as an integral unit, planned by a single authority with

* National Parks and Access to the Countryside Act, 1949. Third Report of the National Parks Commission for the Year ending 30th September, 1952. Pp. iv+30. (London: H.M.S.O., 1952.) 2s. 6d. net.

distinct principles and purposes in view, and it sticks to this point; although it admits that the existing arrangements, with one exception, have worked fairly satisfactorily.

With regard to the exception, namely, Snowdonia, the Commission records great disappointment that no administrative system has yet been established and therefore no progress whatever made in carrying out the purposes for which the Park was designated. The course of the opposition of the three county councils to a joint board down to the statement by Mr. Harold Macmillan, the Minister of Housing and Local Government, in a letter to the County Councils dated April 25, 1952, saying that he could not doubt that the National Parks Commission was right in believing that a national park ought to be administered by one authority, has already received comment in these columns (see *Nature*, 170, 333; 1952). It would appear from the report, however, that the Minister did not receive from the Councils, in their reply of August 5, 1952, the detailed assurances which he requested as a condition of accepting, for an experimental three years, the joint advisory committee they proposed, and that they did not satisfy him that their proposed arrangements would secure the efficient administration of the Park during that period. When consulted on the replies, the Commission again had occasion to say that it could not advise the joint advisory committee method and that in its opinion the only satisfactory machinery is a Joint Planning Board; the Commission's report indicates that the Minister is again corresponding with the three Councils.

A first task of the Park Planning Authorities already appointed is the preparation of a development plan, and Mr. Macmillan has extended until December this year the period allowed to the Planning Boards of the Peak Park and the Lake District for submitting their plans. The National Parks Commission has already received from the Peak Park Planning Board a comprehensive statement of its general proposals: surveys for the development plan will be conducted so as to marshal information for future action for the preservation of the area and the promotion of facilities for open-air recreation, and particular attention will be paid to the survey of existing defacements and of advertisements, of woodland areas for preservation and of areas for planting or afforestation, of historic and interesting buildings, and of areas suitable for camp sites and parking places. The Lake District Planning Board has also outlined the main considerations on which its development plan will be based and its approach to the problems of development control in the National Park.

The National Parks Commission has been consulted upon a large and urgent volume of projected developments, principally relating to electrical development, forestry and mineral workings. Several important safeguards were included in the British Electricity Authority's Hydroelectricity Bill following discussions between the Commission and representatives of the Ministry of Housing and Local Government, the Ministry of Fuel and Power and the British Electricity Authority. In regard to overhead lines, the Commission indicates in an appendix the conditions under which it considers that capital restrictions should not be allowed to exclude relatively short lengths of underground line which is strongly desirable on amenity grounds. Consultation with the Forestry Commission has usually resulted in mutually satisfactory decisions, but a proposal to acquire and afforest about a thousand acres of one of the finest stretches of moorland scenery at Saltersgate in the area designated as the North York Moors National Park was opposed and submitted to the Minister of Housing and Local Government. The Commission records its full agreement with the policy of the Peak Park Planning Board in regard to mineral workings and endorses the view that, while quarrying in the Peak cannot be excluded, the demands of the industry should receive the closest scrutiny and that any additional areas required for limestone quarrying, over and above those already worked, should, wherever possible, be found outside the National Park. The Commission also indicates its approval of the policy adopted by the Peak Park Planning Board to ensure the protection of the amenities of the Park against unsightly and sporadic growth of camping sites, without discouraging legitimate camping for recreational purposes.

FORMATION OF FIBRES FROM PROTEIN MONOLAYERS

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WHEN a monomolecular film of protein at an air/water interface is compressed beyond a certain critical surface pressure it can no longer be re-expanded to its original area, due to the formation of intermolecular linkages by the unfolded film protein. As the film is further compressed, more such linkages occur, and the film 'buckles', or folds up on itself, parallel to the compressing surface (normal to the direction of compression). These regions of folding soon become visible as tiny striations running across the width of the trough[1]; continuing the compression results in the approximation and adlineation of these folds until nothing remains of the film but a solid, fibrous thread which can be picked up entire from the aqueous substratum. This process was first described by the Bordelaisian botanist, Henri Devaux[2], and is commonly called the Devaux effect[3]. It was mentioned somewhat later by Cockbain and Schulman[4].

The use of these fibres in the study of the biological properties of proteins has been demonstrated by Mazia[3], Hayashi, and the latter's collaborators[5–7]; fibres of pepsin, catalase and rabbit actomyosin have been shown to retain the specific biological activities of the unspread protein. The fibres have been shown to consist of microscopically visible 'fibrils' which appear as discrete birefringent units parallel to the fibre axis[3]. It is to these 'structural units' that Hayashi attributes the ability of his actomyosin fibres to contract against a load in the presence of adenosine triphosphate[7], despite the fact that these fibrils merely represent regions where the original film has buckled during the compression, as shown by his own electron microscopic studies[3].

In our experiments on the effect of ultra-violet irradiation of monolayers[8] and dilute solutions[9] of crystalline ovalbumin, we have reported that during the irradiation the fibres formed become increasingly thin and fragile, until finally the irradiated protein loses entirely its ability to form such a fibre. We have shown that the effect of ultra-violet light on this protein is first a non-proteolytic alteration in

molecular structure, followed by a photochemical rupture of peptide linkages (proteolysis). A re-examination of our results shows that the protein has lost its ability to form a strong fibre before any appreciable proteolysis has occurred; we have thus been led to the hypothesis that a non-proteolytic structural modification causes either loss of ability to form fibres, or to the formation of fibres of altered appearance and properties. We have re-opened this question and have recorded the following qualitative observations on the effect of pre-treating ovalbumin with typical 'denaturing' agents. It should be noted that none of these agents prevents film formation; indeed, an aliquot of protein will spread to a larger area following ultra-violet irradiation[8,9], and Stallberg has found[10] that treatment in the boiling water-bath increases slightly the area to which an aliquot will spread, provided, of course, that coagulation is prevented.

If 0·01 per cent ovalbumin solutions at *p*H 2·25 are treated in the boiling water-bath, or by ultra-violet radiation, and then spread at *p*H 4·8 as described[8], fibres are difficult or impossible to obtain, unless a great excess of protein is allowed to become adsorbed at the interface; in this case, the fibres recovered are easy to distinguish from the controls by their fragility and thinness, and, microscopically, by the presence of short, disoriented broken fibrils interspersed in disordered granular regions in which fibrils are absent altogether. Treatment of a 0·01 per cent protein solution with concentrated urea abolished fibre-forming ability; urea treatment of a 1 per cent solution, on the other hand, led to recovery of thick, continuous, but quite fragile, fibres of totally different appearance from the controls. The former resembled a dense, white granular gel and upon drying were usually devoid of any microscopically recognizable structure and were largely non-birefringent when viewed between crossed nicols. Dialysis of the excess urea prior to spreading does not change the appearance of the fibres eventually formed, which are likewise devoid of any fibrillar substructure and after drying are unable to alter the ellipticity of polarized light.

Fibres formed from untreated protein are tough and, when wet, intensely birefringent at the 45° position between crossed nicols. Extinction occurs when the fibre axis is at right-angles to, or parallel to, the plane of the polarized light. After prolonged dehydration, birefringence is still present, but is of reduced magnitude. In this respect, these fibres are similar to those prepared by the crystal method of White and Elmes[11].

It is interesting to note that certain untreated proteins are evidently unable to form fibres at all, despite the formation of perfectly good films. We have not been able to induce insulin films to form fibres, thus confirming a remark by Wrinch[12]. Gliadin films can be made to form fibres only with the greatest difficulty and then by spreading an excess of a 1 per cent solution.

Egg albumin, although known as a difficult protein to spread[10], will unfold after eight hours on *M*/15 sodium chloride into a film the thickness of which, calculated from our results (ref. 8, Table IV), is 8 A.; these films yielded tough, elastic fibres. Urea, ultra-violet radiation, ozone and heat—agents which modify the structure of the intact molecules and eliminate many of their specific properties—either abolish their capacity to combine into fibres after adsorption at the air/water interface or cause the formation of fibres lacking the characteristic regular fibrillar substructure. Hayashi is thus correct in attributing structural significance to these so-called fibrils, since they are absent or much changed in fibres formed from protein previously treated with the usual 'denaturing' agents. The prevalent view[13] that interfacial unfolding of protein is the same sort of process as that caused by other forms of 'denaturation', differing only in that it is a more drastic form of structural modification, seems to be inconsistent with these facts. Our results rather suggest that interfacial unfolding leaves the protein molecule with a measure of two-dimensional specificity not to be found following modification with other agents. The large literature (cited in ref. 6) showing retention of biological (enzymatic, hormonal, antigenic) activity by fully unfolded protein molecules would seem to reinforce this interpretation. It is supported likewise by the work of Schaefer[14], showing definite changes in indicator oil expansion patterns in films spread from previously 'denatured' protein; it may be significant that insulin and gliadin showed expansion patterns indistinguishable from those of other proteins which had been previously modified by treatment with heat or ultra-violet radiation.

Full experimental details of the work of which this is a part are to be published elsewhere. [Sept. 2.

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OPTICAL DESIGN OF DOUBLE-BEAM SPECTROMETERS

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As a result of recent work on a fast-scanning double-beam spectrometer[1], which gave opportunities of examining beam balance over a range of wave-lengths while adjustments were being made to the optical system, two fundamental and rather obvious conditions were proposed which should be fulfilled by any adequate design. These were: (i) that in any plane in which the source or monochromator slits form an image the light distribution should be the same for both beams; and (ii) that in any plane in which the collimator or field forms an image the light distribution should be the same for both beams.

Non-fulfilment of the former may lead to an effect by which a displacement in wave-length occurs between the spectra of the two beams. Equality of the beams is therefore more difficult to obtain the more rapid the rate of change of energy with wave-length in the spectrum. In place of strict equality of the beams at all wave-lengths, a difference spectrum appears which resembles a differentiated version of the energy – wave-length relation for one of the beams alone.

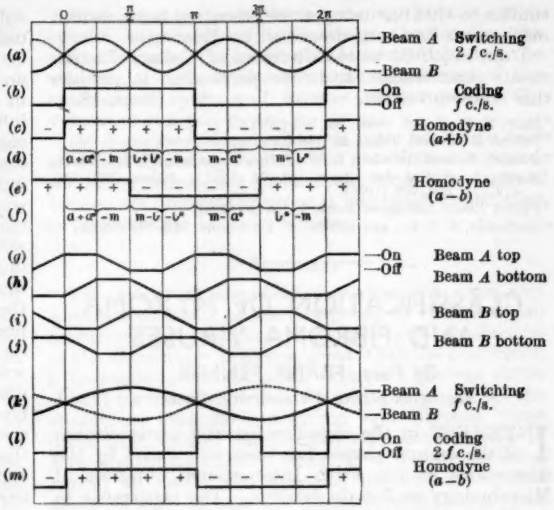
When the second condition is not fulfilled, any variations, within the radiation field, of transmission of prism and windows or of reflexion of mirrors may lead again to an inequality of the beams which varies with wave-length. This effect exhibits a rather slow change with wave-length and tends to become more pronounced as a prism transmission limit is approached.

These conditions are of fairly general application and have been used, as indicated by the following examples, in the design of a conventional recording infra-red spectrometer.

In obtaining a percentage transmission plot in a double-beam infra-red spectrometer, the null-balance method described by Lehrer[2], Wright and Herscher[3] and many others is convenient and widely used. In this, a comb-like shutter is introduced into one beam with the object of reducing the intensity of this beam until it is equal to that of the other beam containing the absorbing sample. From the position of this comb along its line of motion normal to the beam, the percentage transmission of the sample is read off. If such a comb is placed at the focus of the beam, it is clear that the first condition cannot be fulfilled, except at 100 per cent transmission, which in practice might be used for beam balancing adjustments and so conceal the effect. If the comb is used near but not at a focus, neither condition will be fulfilled. It may be noted that imperfection in the slits, in the quality of image or curvature compensation, or in uniformity of the radiation detector surface, make it possible for equal radiation powers entering different elements of the slit to produce very unequal effects.

Thus it appears that only a time-sharing type of shutter may fulfil the two conditions perfectly. We have accordingly examined the possibility of using a rotating star wheel to take the place of the comb shutter and to operate at a focus. This shutter has been designed as a wheel having twenty-four approximately triangular teeth disposed around its circumference, the depth of the teeth being 50 mm., which is thus the traverse required to cover the 0-100 per cent transmission range. It is necessary that the rotation of this wheel should be synchronized with the beam-switching mechanism, and also that several complete revolutions of the wheel should take place during one beam-switching cycle, to avoid errors arising from eccentricity or imperfections of the teeth. Such a shutter, of correct tooth form, will have negligible error on small slit-widths but will be subject to the averaging and end errors, arising at large slit-widths, which are common to both the space-sharing and time-sharing types of shutter.

A second application of the conditions arises in the adaptation of the principle of the multiple-pass monochromator described by Walsh and others[4–6] to a double-beam spectrometer. The design which we have adopted is based on a beam-switching mechanism consisting of continuously rotating sector disks giving a switching frequency of 2 f c./s. and a coding shutter (the equivalent of the chopper used in Walsh's arrangement) operating at f c./s. and synchronized with the beam switch. Two homodyne detectors, one synchronized with the coding shutter and one $\pi/2$ out of phase with it, give outputs from which the stray light components have been eliminated and which correspond to the sum and difference of the two beams respectively, the sum output being used to control recording speed and the difference output to control the null-balancing and recording servo-mechanism.



Phasing relations between beam switch, coding shutter and homodyne gates are indicated by the accompanying chart. For mechanical reasons the beam switch gives a gradual change-over from beam A to beam B and back, as shown at (a), while the coding shutter gives a rather rapid change-over indicated at (b). Homodyne detector gating signals are shown in (c) and (e), + indicating passage unchanged and − inversion of the signal. Using a notation in which a represents the intensity of the wanted component of beam A and a^* the stray component, b the wanted component of beam B and b^* the stray component, and m the mean intensity over the cycle, the homodyne outputs are shown by (d) and (f). the D.C. output-level being proportional to the algebraic sum of these over one complete cycle.

It is necessary, in order to fulfil the optical conditions, that the duration of irradiation of each element of the collimator should be the same for beams A and B. That this is the case may be inferred from (g) to (j), in which the intensities of illumination of the top and bottom halves of the collimator are indicated diagrammatically for both beams. When the illuminated portions occurring in the second quadrant are subtracted from those occurring in the first quadrant, it is seen that those parts during which the illumination is changing cancel out, leaving full illumination of the collimator by beam B for $\frac{1}{2}$ cycle to be subtracted from full illumination of the collimator by beam A for $\frac{1}{2}$ cycle. It is evident that the cancellation of stray light will be efficient, since the beam switch is in the same phase during the two quadrants for which signals are subtracted in the homodyne detector.

Mechanical considerations might suggest that operation of the beam switch at f c./s. and the coding shutter at 2 f c./s. would be preferable; but it will be seen that such a system, though otherwise practicable (see (k) to (m)), does not fulfil the optical conditions, the net effect being that in the a–b homodyne case the top half of the collimator is used for one beam and the bottom half for the other. A system

similar to this but using a reciprocating beam switch mechanism has been described by Rochester.

I am indebted to the directors of Unicam Instruments (Cambridge), Ltd., for permission to publish this communication. [Sept. 18.

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CLASSIFICATION OF MYXOMA AND FIBROMA VIRUSES

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INTEREST in the classification and nomenclature of the animal viruses has been stimulated by the discussions at the Fifth International Congress of Microbiology at Rio de Janeiro[1]. The occurrence in Australia during the summer seasons of 1951 and 1952 of severe and widespread epizootics of myxomatosis among the wild rabbits[2] has redirected attention to this virus, and it is appropriate to consider the question of its classification, that is, its relationship to other animal viruses.

Eight criteria to be applied in classifying animal viruses were laid down by the virus sub-committee at Rio de Janeiro. We will discuss these in turn, and see if light can be thrown on the classification of myxoma virus in this way.

(1) *Morphology and method of reproduction.* There is general agreement that morphology and size are among the most important features in the determination of the broad (generic) relationships of the animal viruses. Stained smears of the elementary bodies of myxoma virus[3] and fibroma virus[4] showed that they resembled vaccinia virus in their size and shape.

Only one study[5] of myxoma virus with the electron microscope has been published, and no electron micrographs of fibroma virus have been printed. However, recent work[6] extends our knowledge of the morphology of these viruses. The elementary bodies of myxoma virus were found to measure 286 μμ × 230 μμ by Farrant and Fenner[6], and 287 μμ × 233 μμ by Ruska and Kausche[6], dimensions almost the same as those of vaccinia virus elementary bodies photographed under the same conditions. More careful examination of metal-shadowed elementary bodies of myxoma virus revealed the central 'condensation' observed also in vaccinia and fowlpox viruses. Treatment with pepsin produced the appearance of a clearly defined central body which resisted peptic digestion[6]. Similar results have been obtained after pepsin treatment of vaccinia[7] and fowlpox[8] viruses. Bang[9] found that, in electron micrographs of sections of chick chorio-allantoic membrane, elementary bodies of myxoma virus were indistinguishable from those of vaccinia virus[10].

It is clear that myxoma is almost the same size, and has the same external shape and internal architecture, as vaccinia and fowlpox viruses.

A few exploratory investigations have been made of the mode of reproduction of vaccinia virus. Infectivity titrations at frequent intervals during the first forty-eight hours, using the chorio-allantoic membrane of developing chick embryos[11] and tissue cultures of the rabbit skin[12], have been interpreted as demonstrating that the same sequence of events occurred as had been found with bacterial viruses[13] and influenza virus[14]. There was a sharp reduction in the amount of infective virus immediately after infection, and no increase could be detected for about eight hours[11] or ten hours[12]. Briody and Stannard[11] observed another sharp rise sixteen hours after the initiation of infection. Preliminary experiments[12] with myxoma virus grown on the chorio-allantoic membrane gave results very similar to those obtained with vaccinia virus. Less than 1 per cent of the inoculated virus could be recovered from the membrane during the first six hours after inoculation. Demonstrable unabsorbed virus and losses during the preparation of the membrane suspension accounted for only 8 per cent of the 'lost' infectivity, so that with myxoma virus also there is an unexplained disappearance of infective virus during the first few hours after inoculation. Eight hours after inoculation there was a slight increase in the infective titres of the membrane suspension, of doubtful significance, and between the sixteenth and twentieth hours the titre increased a hundredfold. The results with both vaccinia and myxoma are too fragmentary to allow any definite conclusions to be drawn concerning their mode of reproduction, but so far no inconsistencies in the behaviour of the two viruses have become apparent.

Studies have also been made of the life-cycle of vaccinia virus in the chorio-allantoic membrane of the chicken embryo with the electron microscope[10,15,16]. The most important conclusion derived from these investigations is that the nucleus probably plays an important part, for the earliest virus particles appear to form at the nuclear wall. No reports have been published of the appearances of cells infected with myxoma virus.

(2) *Chemical composition and physical properties.* The only chemical study made of myxoma virus is that of Balls *et al.*[17]. They found a peculiar lipoid (not cholesterol) in the centrifuged deposit of an elementary body preparation. The nitrogen, phosphorus and lipoid content of this sediment were much the same as the corresponding figures for vaccinia virus and the Rous sarcoma virus.

Schlesinger and Andrewes[18] carried out filtration and centrifugation experiments with fibroma virus. They found that the diameter of the virus, estimated by filtration through graded membranes, was about the same as that of vaccinia (125–175 μμ) and by centrifugation 126–141 μμ. The specific gravity of the virus was estimated at 1·3.

(3) *Immunological properties.* Myxoma and fibroma viruses are closely related antigenically[19], and myxoma virus, which has been investigated in some detail[20], is antigenically complex, having at least two soluble antigens. Neither virus appears to be capable of agglutinating red blood cells[21].

There is no immunological relationship between myxoma virus and vaccinia virus, and no antigenic comparisons have been made with other viruses of the same size and shape.

(4) *Susceptibility to physical and chemical agents.* One of the few satisfactory studies of heat-inactivation of animal viruses is that of Bronson and Parker[22] with myxoma virus. Because no comparable data were available on other viruses of the same size and shape, similar investigations were carried out with a number of viruses of the pox group[22]. Some of the results are summarized in the accompanying table. They are expressed as the time required to inactivate,

TIME (IN MINUTES) REQUIRED TO REDUCE THE INFECTIVE TITRE OF SUSPENSIONS OF VIRUS IN NORMAL RABBIT SERUM FROM 10^9 TO ZERO, BY HEATING AT 55° C. THE RESULTS OF DUPLICATE EXPERIMENTS ARE SHOWN

Myxoma	Fibroma *O.A.*	Vaccinia		Cowpox	Ectromelia	Fowlpox
		Gillard	Mill Hill			
24, 25	11	82, 74	125, 155	62, 53	48, 42	54, 45

by heating at 55° C., suspensions of a number of viruses in normal rabbit serum, the initial concentration in all cases being 10^7 infective particles/ml. The figures shown were determined by extrapolation of the straight lines obtained when the infectivity (on a $\log_{10}$ scale) was plotted against the time of heating. There was some variation between different strains of vaccinia virus; but myxoma and fibroma viruses appeared to be more susceptible to inactivation by heat than any of the other viruses tested.

Andrewes and Horstmann[24] regard resistance to ethyl ether as a property which might be useful in the classification of viruses, since in many cases it runs parallel with distinctions made on other bases. We[25] were able to confirm their observations of the sensitivity of myxoma and fibroma viruses, and the resistance of vaccinia, fowlpox and ectromelia viruses to ethyl ether. However, when a number of viruses were tested for inactivation by certain surface-active agents (sodium lauryl sulphate, sodium deoxycholate, and saponin)[26], myxoma virus was found to resemble fowlpox, vaccinia and ectromelia viruses and to differ from a number of other viruses in the high degree of resistance it showed to these chemicals.

(5) *Natural methods of transmission.* The natural method of transmission of fibroma virus is not known, though it may well be mechanical carriage by insect vectors[27]. Myxomatosis may be transferred by contact[28] or by exposing rabbits to a virus-containing mist[29]; but in Nature transmission is effected principally by insect vectors[2] and, at least in the most important vector, the mosquito, is purely mechanical in nature, being due to contamination of the mouth-parts by virus in the skin lesions[30]. The modes of transmission of myxomatosis are quite similar to those of fowlpox[31].

(6) *Host, tissue and cell tropisms.* Both myxoma and fibroma have a limited host-range, rabbits of the genus *Sylvilagus*[32,33] and *Oryctolagus*[32,34], the developing chick embryo[35,36] and the developing duck embryo[37] being the only susceptible hosts. While vaccinia has a very wide host range, other characteristic members of the pox group (variola, mousepox) have a restricted host range.

Both myxoma[38] and fibroma[39] cause a generalized disease in the laboratory rabbit, which is characterized by a primary lesion at the site of inoculation of the virus and secondary localization in the skin about a week later[40]. This train of events resembles closely that encountered with mousepox[41], and vaccinia in rabbits[42].

(7) *Pathology, including formation of inclusion bodies.* The strains of myxoma and fibroma viruses isolated from naturally occurring cases induce at first proliferation in the cells which they attack, followed later by necrosis. A variant strain of fibroma virus (*LA*) causes inflammation and necrosis from the outset. While these properties have led many investigators in the field of oncology to study the myxoma and fibroma viruses, they cannot be considered as of much importance from the point of view of taxonomy. Vaccinia and fowlpox viruses also cause hypertrophy and hyperplasia of infected cells[43].

Both myxoma and fibroma viruses produce acidophilic intracytoplasmic inclusion bodies in the epithelial cells of infected skin lesions[44,45], and in the ectodermal cells of the chorionic membrane of the chicken embryo[46], and in this they resemble the viruses of the pox group.

(8) *Symptomatology.* There is little left to be said of symptomatology which has not been mentioned earlier. Virologists concerned with the animal viruses are doubtful whether it has much importance in classification of these viruses.

Summary

The points of resemblance of myxoma virus and accepted members of the pox group of viruses are so numerous, and the detailed morphological similarities of the elementary bodies so great, that the conclusion is inescapable that myxoma virus (and fibroma virus) should be included within the pox group. Of all the characters examined, myxoma and fibroma virus differ from viruses like fowlpox and vaccinia only in their sensitivity to ethyl ether. It would appear more logical to doubt the absolute importance of this property than to base the exclusion of myxoma virus from the pox group upon it.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

A Fast and Efficient Neutron Detector

Measurements of the variation of neutron cross-section with neutron energy have been made at Harwell using an electron linear accelerator pulsed neutron source, and a time of flight spectrometer technique[1]. In these measurements a boron trifluoride proportional gas counter was used, and in order to obtain an adequate efficiency of detection it was necessary to use a rather large gas volume. This counter limited the neutron energy resolution in two ways: at low neutron energies (10 eV.) the counter length of 50 cm. was the main indeterminacy in the neutron flight distance, and at high neutron energies (keV.) there was the additional and larger indeterminacy in the ion collection time in the counter.

Various alternative detection methods have been tried with the object of combining a more rapid response with increased neutron capture, and it now seems necessary to adopt some form of scintillation detector containing boron[2,3]. In the present investigation, the most promising substance tried was borazole[4], $B_3N_3H_6$. Solutions of borazole in *para*-xylene, with *para*-terphenyl added to a concentration of 5 gm. per lit., have the following useful properties: (1) processes of exciton transfer in xylene are not quenched by the borazole; (2) scintillation pulses obtained by irradiation with polonium alpha-particles are proportional in intensity to the molar concentration of xylene; (3) scintillation response time is less than 10^{-9} sec. Thus, for example, an equimolecular solution of borazole in xylene is a detector with a boron density increased by a factor of 400, and a response time shortened by a factor of 100, when compared with the boron trifluoride counter.

I am indebted to Mr. W. L. Borrows, of the Admiralty Research Laboratory, Teddington, for the preparation of the borazole. I also wish to thank Dr. K. W. Bagnell for information about borazole and guidance on boron chemistry, and to acknowledge the help and encouragement given by Dr. E. Bretscher and Mr. G. N. Harding.

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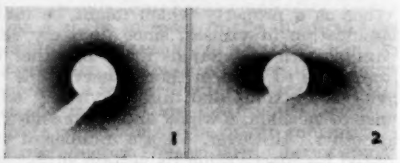
Low-angle X-Ray Diffraction of Bone

The study of diffuse scattering of X-rays at low angles has been used for evaluating the size of crystallites and of particles[1]. We have applied this technique to bone tissue in order to study the arrangement of hydroxylapatite crystallites in this structure.

Earlier wide-angle investigations have shown that the *c*-axis of the hydroxylapatite unit cell is parallel to the fibre axis of the collagen[2]. This arrangement can also be demonstrated in *in vitro* experiments[3].

Longitudinal- and cross-sections of compact bone from several animals were prepared by grinding. The sections were about 0·1 mm. thick. Both wide-angle and low-angle diffraction patterns were registered simultaneously on films placed at different distances from the sample. Nickel-filtered copper radiation was used. In Fig. 1 is shown the low-angle diffraction pattern from a cross-section of bone, and in Fig. 2 the pattern from a longitudinal section (longitudinal axis of bone is vertical). The wide-angle and low-angle diffraction patterns from cross-sections showed no appreciable orientation, but in the case of longitudinal sections the low-angle scatter showed marked equatorial orientation, and the 002 reflexion in the wide-angle pattern showed meridional intensifications. In bone, therefore, the hydroxylapatite crystallites are elongated with their long axes parallel to the collagen fibres.



Estimations of the short dimension of the crystallite (the width) gave an approximate diameter of 60–80 A. When estimating the long dimension of the crystallites, the small-angle meridional diffraction of the collagen interferes. Several orders of a fundamental spacing of about 660 A. were obtained from the intact bone tissue. The long dimension is estimated to be about three times the width.

Full details of this work will be published elsewhere.

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Shadow Microscopy for Measurement of Height

This note describes a simple optical microscope shadow technique which permits measurement to be made of the heights of small objects such as particles, spores, steps on surfaces, etc., and also reveals qualitative surface topographical features in a striking manner. This is an optical analogy to the familiar metallic shadow-casting method which is used with electron microscopes. I have used it with powers up to that of a 4-mm. objective.

When an object on a specially prepared slide on a microscope stage is illuminated by a parallel light pencil at incidence near to grazing, then a reasonably sharp long shadow is cast on to the slide. Provided the object is appreciably larger than the wave-length of the light used, then the ratio of shadow-length to object-height is the tangent of the angle of incidence. For grazing angles of 5° and 3° the respective lengths

Fig. 1. Lycopodium and *Trichoderma viride* spores: microscope, × 240; shadow, × 12; total, × 2,900. (Reduced in reproduction to about a half)

of shadows are some 11 and 19 times the object height. Thus with a microscope magnification × 500, the magnification of height in a shadow at incidence slightly less than 3° has the astonishing value of × 10,000. Such magnifications are not always necessary, but are available if needed.

A bright parallel beam of some 1 mm. diameter is projected on to the object by a lens stopped down with an iris. The angle of incidence, and thus the shadow-length magnification, is adjustable by raising or lowering the illuminating lens. The angle of incidence need not be measured, as the introduction into the field of view of approximately spherical particles of measurable diameter secures calibration for any particular illumination set up, irrespective of the power of the microscope objective used. Thus any convenient spherical particles can be used for establishing the shadow magnification, for then the visually observed diameter is equal to the height. Alternatively, the ratio of length to width of shadow gives the magnification ratio.

Lycopodium powder is quite suitable for this purpose as the particles are reasonably spherical and easily measured.

An essential basic feature of this technique lies in the correct preparation of the surface receiving the shadow. This will usually be either (*a*) a slide to receive small objects such as particles, filaments, grains, crystals, biological objects, etc., (*b*) the surface of, say, a crystal, metal or some other extended object with topographical features on it. The surface receiving the shadow must be a reasonably flat fine-grain scattering surface. For example, if lycopodium be scattered on to a glass slide, shadow-casting illumination will produce no shadow at all. The system behaves like dark-ground illumination pushed to the limit and one sees the brightly illuminated particles, without any shadow, for no light scatters up to the microscope from the polished glass surface. A number of suitable surfaces have been developed, but by far the best is to deposit on a slide a layer of silver and then expose this to aqua regia vapour, which converts it into a cloudy white matt fine-grain deposit, capable of producing shadows of high definition when particles are placed on it. The fine grain is the important point. To examine the topographical features of, say, a crystal, this is first coated with silver and then exposed to the aqua regia vapour, thus creating the matt surface *in situ*. The dark shadows for particles will often be bordered by brighter diffraction edges. By photographing on to a reasonably contrasty plate a sharp clean finish to the shadow obtains and both shadow-length and -width can readily be measured.

Fig. 2. Growth shelf on diamond octahedron face: microscope, × 210; shadow, × 12; total, × 2,500. (Reduced in reproduction to about a half)

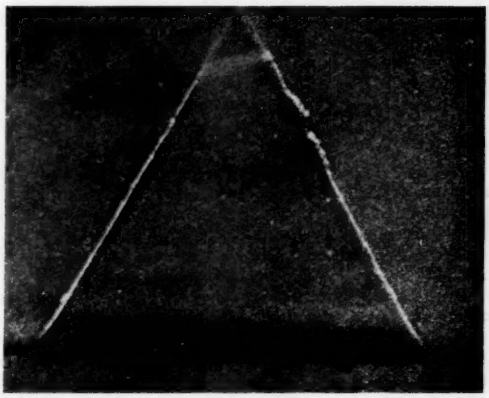

Fig. 3. Hollow growth trigon on diamond octahedron face: microscope, × 210; shadow, × 12; total, × 2,500. (Reduced in reproduction to about a half)

Typical applications are shown in the accompanying figures. Fig. 1 shows spores of *Trichoderma viride* and a lycopodium particle using × 240 magnification in the microscope. The magnification in shadow is × 12, which makes the total effective magnification of height about 2,900 in the shadow. Fig. 2 shows at × 210 and shadow magnification at × 12 growth shelves on a diamond octahedral face. A further example in which total shadow magnification is also × 2,500 is shown in Fig. 3, which is a hollow trigon depth about 3 μ. When such an object rotates, the shadow of a ledge sweeps round, vanishing when the ledge is parallel to the direction of the incident light pencil. On further rotation the front of the ledge then becomes a brightly illuminated wall and there is still no shadow.

It is clear that this shadow technique has wide applications. An experimental study is being made now of the lower limit of height which will reveal a detectable shadow. It is to be expected that diffraction will confuse the situation considerably for very small particles and this is under examination.

This is largely a technique for studying features above the general level, that is, particles, hillocks, shelves, elevations, etc., rather than one for looking into hollows, unless in fact the hollow has a much larger flat bottom extension than its height. In some cases contrast is decidedly improved by plane polarizing the illuminating beam, largely through cutting out scatter from the object.

It should be noted that the shadows of single particles may at times be forked or show a multiple structure, revealing thus unsuspected peaks or valleys on the surfaces of the particles. The patterns given by transparent crystallites require to be interpreted with reference to the possible transmitted light which can appear within the centre of the shadow.

Quite apart from the height-measuring capabilities of this system, the grazing illumination on the fine-grain matt surface turns out to be a new vivid technique for revealing topographical features by creating new contrasts. It is, of course, a modified form of controlled and heightened dark-ground illumination. One sees far more by this technique than by direct microscopy.

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Feb. 17.

Polarized Ultra-Violet Absorption of Anthracene

Theoretical calculations of π-electron states in aromatic molecules give values for three important properties of spectral transitions. These are the wave-length, intensity and polarization of the band systems which correspond to jumps between the calculated states.

Finding the polarization of observed band systems to check the calculations is more difficult than finding the wave-length and intensity, and has not often been attempted in aromatic hydrocarbons except in the weakest band systems, for which quite thick crystals give measurable optical densities[1,2]. However, by working with the thinnest sublimation flakes that could be transferred without shattering to a silica plate, we have now measured the polarizations of some stronger systems in the near ultra-violet spectrum of anthracene.

The thinnest of these crystals show retardations under the polarizing microscope of less than 100 $\mu\mu$ and are pale gold, or occasionally blue, by reflected light. Their thickness is of the order of 0·1 μ. Specimens examined by X-rays invariably show that the developed face is a (001) plane, and this contains the *a*- and *b*-crystal axes which are mutually perpendicular. The positions of the *b*-axis were found either by means of X-rays or microscopy, and the crystal mounted on a rotating stage with its face perpendicular to the optic axis of a Hilger Littrow quartz spectrograph. Light passed through the crystal into a quartz Wollaston prism and on to the slit, the two beams of plane-polarized light being about 4 mm. apart. The optical densities for the two directions of polarization were measured by sector photometry against equally long exposures of the light source without the crystal. The ratio of these optical densities for electric vector directions parallel to the *a*- and *b*-crystal axes was compared with that calculated from the known inclinations of molecular axes within the crystal.

The spectral range accessible to the quartz spectrograph includes three regions of absorption, each corresponding to a distinct band system of anthracene. In the systems at 3800 A. and 2700 A., absorption is greater for the electric vector parallel to the *b*-crystal axis; in the system at 2300 A. absorption is less for the *b*- and greater for the *a*-direction. These results cannot at once be put in terms of molecular axes, since three molecular axial directions cannot be characterized from two crystal directions. However, much evidence suggests the inactivity in transitions in the near ultra-violet of one of the molecular axes, namely, that normal to the plane of the rings; and if this inactivity be accepted, it follows from our results that the band system at 2700 A. is polarized along the shorter in-plane axis, that the system at 3800 A. has at least a strong component along this axis, and that the system at 2300 A. is polarized along the longer in-plane axis.

There is clear evidence in the 3800 A. band system of the displacement of the absorption maxima in *a*-polarization from those in *b*-polarization, so that the whole band system appears to be displaced as well as changed in intensity, as the polarization direction of the incident light changes in the *ab* face. The split maxima have separations in the range 50–100 cm.$^{-1}$. This may be the phenomenon, a theory of which was first given by Davydov[3], in which intermolecular forces split the molecular energy-levels into pairs of crystal states with different polarization properties.

These preliminary results will later be incorporated in a more complete report. We wish to acknowledge valuable discussions with Prof. C. K. Ingold. We have also received important help from Dr. H. G. Poole, who designed the optical arrangements, and from Mr. Philip Knight, who made several X-ray examinations of anthracene crystals and so made possible their correct orientation in the light beam.

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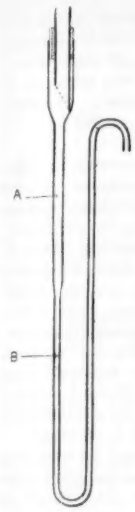
Estimation of the 9 : 10-Dihydroxystearic Acids and their Acyl Derivatives

The occurrence of esters of 9 : 10-dihydroxystearic acid (melting point, 132°) among the autoxidation products of oleic and elaidic acids has been established by Ellis[1], who utilized the sparing solubility of the dihydroxy acid for its isolation and estimation. In the presence of a high proportion of oily products, however, a quantitative separation of the acid is sometimes difficult, and the presence of silica following prolonged alkaline hydrolysis may also be a source of error.

The method of estimation to be described takes advantage of the fact that, under suitable conditions, periodic acid oxidizes the 9 : 10-dihydroxystearic acids almost quantitatively to nonaldehyde and azelaic semialdehyde[2], of which the former may readily be isolated by distillation in steam and its



volume measured. The reaction is best carried out in feebly alkaline solution, avoiding an unnecessary excess of periodate. Thus, an amount of material containing not more than 1 gm. of dihydroxystearic acid is dissolved in 100 ml. of seminormal sodium hydroxide and brought to *p*H 8 with dilute sulphuric acid. After adding 0·2 gm. (0·75 gm. if the amount of dihydroxy-acid is thought to exceed 0·25 gm.) of potassium periodate, the solution is distilled at a moderate rate through a simple water-cooled condenser into a trap (see diagram), in which the non-aldehyde collects as a nearly insoluble oil on the surface of water in the tube *A* (bore 3·5 mm.; length 7·5 cm.), while the aqueous part of the distillate siphons over into a measuring cylinder[1,2]. When no further aldehyde distils over and some 20 ml. of water has been collected, the trap is detached and the oil run into the capillary *B* (bore *c.* 1·75 mm.), where its depth is accurately measured after standing for 10 min. or more. The capillary may be calibrated by oxidizing pure dihydroxystearic acid (melting point, 132°) under the same conditions; or, if the bore of the capillary is known, the mass of non-aldehyde (*d*, 0·827) can be calculated, an allowance of 0·001 gm. being made for its solubility in 20 ml. of aqueous distillate. The yields of nonaldehyde (Table 1) range from 82 to 95 per cent of the theoretical and, except for very small amounts, are reproducible to within ± 2·5 per cent; but it is important that the still and trap should be cleaned with chromic-sulphuric acid and well washed prior to each estimation. The isomeric dihydroxy-acid (melting point 95°) gives almost identical results.

Table 1

(*a*) Using 0·20 gm. of potassium periodate

Dihydroxystearic acid (mgm.)	25	50	75	100	125	150	175	200	225	250
Nonaldehyde (mgm.)	10	18·5	28·5	39	49	59	70·5	84·5	96·5	103

(*b*) Using 0·75 gm. of periodate

Dihydroxystearic acid (mgm.)	100	200	300	400	500	600	700	800	900	1,000
Nonaldehyde (mgm.)	37·5	80	120	163	207	252	295	340	385	422

For the estimation of acyl esters of dihydroxystearic acid, 0·75–1·0 gm. of the material is saponified by refluxing or, where volatile hydrolysis products are formed[1,4], slowly distilling with 100 ml. of seminormal aqueous sodium hydroxide for 2 hr. The cooled solution is diluted if necessary to about 100 ml., brought to *p*H 8 and distilled with periodate as described. When estimating esters in autoxidized oleic or elaidic acid, certain corrections may be necessary. First, elaidic acid oxide, which is normally present[4], is saponified to dihydroxystearate under these conditions to a variable extent. The amounts of nonaldehyde arising from this source are given in Table 2. Secondly, 10-hydroxy-9-ketostearic acid similarly gives a good yield of nonaldehyde on oxidation with periodate[5]; but except during the advanced stages of autoxidation neither this nor free dihydroxystearic acid appears to occur in significant amount in these products, as may be shown by distilling the unsaponified material at *p*H 8 without and with periodate.

Table 2

Elaidic acid oxide (mgm.)	25	50	100	150	200	250	300	400	500
Nonaldehyde (mgm.)	8	9·4	11	12·1	13	14	14·7	16·1	17·3

A few typical results are summarized in Table 3.

Table 3

	Dihydroxystearic acid (per cent)		
	Present, or theoretical value	Found	
		Periodate method	Isolation method
Mixture of dihydroxystearic acid (m.p. 132°), and elaidic acid	20·0	19·9	19·7
Mixture of dihydroxystearic and oleic acids	20·0	19·4	16·2
Mixture of dihydroxystearic and nonanoic acids	66·7	67·8	—
Autoxidized elaidic acid (corrected value)	—	7·0	5·5
Oily fraction of the above, insoluble in *n*-hexane	—	12·4	6·7
Impure mono-azelaate of dihydroxystearic acid, after saponification	65·0	62·2	62·4
9 : 10-Hydroxyacetoxystearic acid (m.p. 81°) after saponification	88·3	85·5	—

The scope of the periodate reaction is well known[6] and the method should be applicable to other suitable 1 : 2-glycols or ketols.

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Hardening of Kaolin on Rehydration

AN investigation of the durability of fired clay minerals revealed an unexpected hardening of kaolin on rehydration. Samples from Gordon, Victoria, fired at 500°–950° C., followed by rehydration in saturated steam at 200° C. for periods up to 96 hr., showed compressive strengths for small cylinders of 5,000–14,000 lb./sq. in., compared with strengths of 1,000–2,000 lb./sq. in. before rehydration. The compressive strength of the kaolin fired at 1,250° C. was 4,000 lb./sq. in.

X-ray analysis of the rehydrated kaolin indicates that the increase in strength may be related to a higher crystal symmetry, since the powder pattern has fewer lines, with k reflexions absent or reduced in intensity. Electron micrographs of the original material before and after firing show well-formed hexagonal flakes, whereas the rehydrated kaolin is composed of clusters of much smaller and more irregular particles similar in appearance to those of the 'third form' of kaolin discussed by Bramao *et al.*[1]. This kaolin, however, differs from the rehydrated material in having a disordered structure.

Differential thermal curves show a large endothermic peak at 130°–150° C., followed by a continuous endothermic reaction up to the main endothermic peak at 550° C., some 70° C. lower than the corresponding peak in the original kaolin. The final

exothermic peak is unaffected. Activation energy for the main dehydration process calculated from the differential thermal curves is about 40 kcal. for the rehydrated kaolin, compared with 55 kcal. for the original material. The slope ratio of the main endothermic peak is 4–1 for the rehydrated material, a figure which has been thought characteristic of halloysite[1]. The slope ratio for the untreated kaolin is 1·25–1.

Preliminary tests on other materials indicate that the hardening effect occurs in relatively well-crystallized kaolins.

Possible industrial applications of the phenomenon are being investigated.

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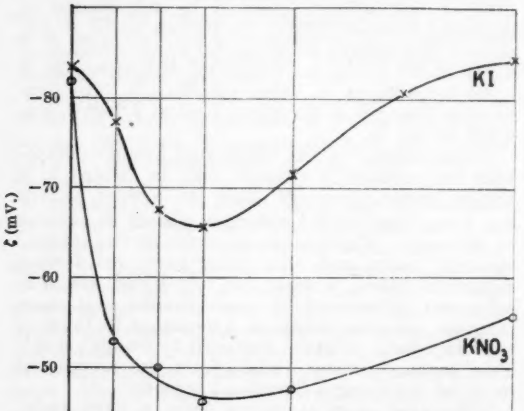
Centrifugation Potentials in Sols of Silver Iodide

If a sol is centrifuged, an electrostatic potential difference is set up between two points in the sol at different distances from the axis of rotation (centrifugation potential)[1]. These potentials are connected with the ζ-potential of the colloidal particles by the formula :

$$V_{C.P.} = \frac{m'n}{\sigma} \frac{D\zeta}{6\pi\eta} \frac{\omega^2}{2} (R_2^2 - R_1^2). \qquad (1)$$

Here $m'n$ is the apparent mass of dispersed substance per cm.^{3}, σ the electrical conductivity, η the viscosity, D the dielectric constant of the sol, ω the angular speed of rotation, and R_2, R_1, the distances from the axis of the two points between which the centrifugation potential is measured. Conversely, from the value of $V_{C.P.}$, ζ can be calculated ; therefore the measurement of centrifugation potentials is of considerable interest.



Values of ζ in sols of silver iodide after the addition of potassium nitrate and of potassium iodide

Extensive measurements of these potentials in sols of arsenic trisulphide have been made by G. Jacobs[2]. One of his results, and certainly the most unexpected, was the shape of the $\zeta - c$ curves for the addition of indifferent electrolyte (potassium nitrate). Between 0 and 3 millimol./l., ζ decreases from − 100 to − 73 mV. and then rises slowly again.

We decided to repeat these measurements, in order to see whether Jacobs's result was a general one, for sols of silver iodide. To obtain the necessary quantities a continuous electrodialyser was constructed[3]. We prepared a concentrated sol, containing 50 gm./l. of silver iodide ; the coarsest particles were eliminated by pre-centrifugation, resulting in a sol of about 20 gm./l. with which the measurements were made.

The results are shown in the accompanying graph ; the reproducibility of the points was about 3 per cent. There is again a strong decrease of ζ, followed by a slow increase, for the addition of indifferent electrolyte ; for the addition of potential-determining electrolyte, there is also a decrease of ζ, followed by a much more marked increase. This last feature is in agreement with expectation, and gives us confidence in the experimental procedure ; the first result is quite unexpected, and, so far as we are aware, cannot be explained by the current theories of the double layer. In fact, these theories always lead to a monotonic change of ζ with concentration.

We are proposing to make simultaneous measurements of ζ and ε (the total potential) in order to obtain more insight into this problem.

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Curves of Succinoxidase Inhibition by Surface-active Agents

Inhibition of the succinoxidase system by a variety of surface-active agents has been noted by Hockenhull[1]. The inhibition of this enzyme system by certain water-soluble androgens has recently been demonstrated[2]. The effect of these androgens suggested a surface phenomenon[3].

Two detergents were therefore studied in this laboratory to compare curves of inhibition with those found for the androgens. Sodium deoxycholate was chosen because it is both an ionic detergent and a soluble steroid salt. Polyoxyethylene sorbitan monolaurate ('Tween 20') was the neutral detergent used. The manometric technique employed was that described in Umbreit's text-book[4]. The accompanying curves (Figs. 1 and 2) show the influence of detergent concentration on the succinoxidase system of rat liver.

The sigmoid shape of these curves is similar to that of curves obtained when sodium androsterone sulphate is the inhibiting agent. If we consider per cent inhibition analogous to uptake of inhibitor by the enzyme system, we may compare the curves obtained here with adsorption curves in other systems. For example, Coolidge[5] found this type of curve for the adsorption of water vapour by charcoal under conditions of increasing vapour pressure. Evidence derived from the work with androgens indicates that

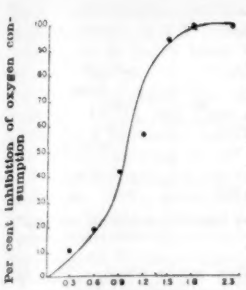

Fig. 1

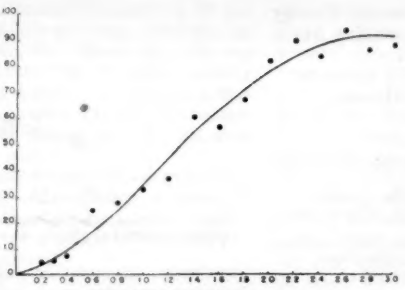

Fig. 2

Fig. 1. Effect of concentration of sodium deoxycholate ion the succinic dehydrogenase system

Fig. 2. Effect of concentration of polyoxyethylene sorbitan monolaurate ('Tween 20') on the succinic dehydrogenase system

succinic dehydrogenase is the target of the inhibitor[3]. It is suggested that the mechanism of inhibition of the isolated succinoxidase system by surface-active agents is due to their adsorption by succinic dehydrogenase.

I am indebted to Prof. W. C. Cutting for helpful suggestions.

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The Trinitratouranyl Complex Ion

SALTS having the general formula $M[UO_2.(NO_3)_3]$ (where M is NH_4, K, Rb, Cs) have been referred to in recent literature[1]. The tetramethylammonium salt has been prepared by reaction of the appropriate nitrates in pure nitric acid medium[2], and the identity of a trinitratouranyl ion has been established in solutions of uranyl and tetra-*n*-butylammonium nitrates in acetone or methyl isobutyl ketone[3].

Comparison of the ease of formation of the trinitrato- with that of the tetranitrato-complex is of importance in the chemistry of uranyl compounds, particularly in view of the unusual co-ordination number apparently involved in the former compound. It is therefore interesting that salts of the trinitrato-complex are formed directly from uranium metal by reaction in liquid dinitrogen tetroxide, under experimental conditions which do not favour the formation of any one particular complex. Reaction between the pure metal and liquid dinitrogen tetroxide is very slow; but when diethylammonium nitrate is dissolved in the tetroxide, reaction becomes rapid, with evolution of nitric oxide. On standing, the liquid deposits transparent yellow-green crystals which contain no combined dinitrogen tetroxide; analysis of this product is in accord with the formula $(Et_2NH_2)[UO_2.(NO_3)_3]$. When a dilute solution of this compound is electrolysed, the ion containing uranium migrates to the anode, confirming that the uranyl group is present in an anionic complex. Using diethylammonium nitrate solutions, this is the only salt which crystallizes. A similar reaction occurs with solutions of mono- or tri-ethylammonium nitrate in liquid dinitrogen tetroxide; with the monoethyl compound the crystalline product varies in composition with concentration of the solution, and is probably a mixture of the salt $M[UO_2.(NO_3)_3]$ with a little of the tetranitratouranyl salt $M_2[UO_2.(NO_3)_4]$. However, the ready formation of the trinitratouranyl complex under these conditions illustrates its high stability in media of low dielectric constant. The complex undergoes ionic dissociation in water.

The rates of the above reactions show large positive temperature coefficients. Again, the rate of reaction between uranium metal and the liquid tetroxide alone is increased by the addition to the tetroxide of other compounds (for example, diethylnitrosamine) able to increase the dielectric constant of the medium. For these reasons (as with metallic zinc[4]) we consider that the initial (rate-determining) reaction involves $[NO^+]$ $[NO_3^-]$ ion-pairs, so that:

$$U + nNO^+ = U^{n+} + nNO$$

On kinetic grounds, n is likely to be a small number. Reaction of the ion with the tetroxide then gives rise to progressive oxidation:

$$U^{n+} \xrightarrow{N_2O_4} UO^{2+} \xrightarrow{N_2O_4} UO_2^{2+}$$

Only the hexavalent uranium salt crystallizes, although the mother liquor contains some uranium in a lower valency state.

Many reactions in liquid dinitrogen tetroxide may be correlated on the basis of a solvent system[5] which involves the ionization:

$$N_2O_4 \rightleftharpoons NO^+ + NO_3^-$$

The salts described above illustrate clearly the amphoteric nature of uranium in this solvent system. The NO_3^- ion is equivalent to the OH^- ion in the aqueous system, and there is a striking similarity between the commonest type of uranate produced in 'basic' solutions of the two media.

H_2O system		N_2O_4 system	
(*A*)	$M_2U_2O_7.3H_2O$		
(*B*)	$M_2[(UO_2)_2.(OH)_6]$	(*D*)	$M_2[(UO_2)_2.(NO_3)_6]$
(*C*)	$M[UO_2.(OH)_3]$	(*E*)	$M[UO_2.(NO_3)_3]$

Treatment of a uranyl compound in aqueous solution with alkali results in the precipitation of the diuranate (*A*). If three molecules of water are regarded as constitutional, the compound may be formulated as (*B*) or (*C*). The analogous compound produced from liquid dinitrogen tetroxide is (*E*), or its dimeric form (*D*). Structures (*B*) and (*D*) are attractive, in that they enable the compounds to be formulated as binuclear complexes of 6-co-ordinate uranium, although crystal structure determinations on the compound $Rb[UO_2.(NO_3)_3]$ indicate that in this salt the uranyl complex is mononuclear[6].

We wish to thank the Director, Atomic Energy Research Establishment, Harwell, for making available a supply of pure uranium metal.

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Sept. 26.

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Reversible Dissociation of Insulin

In the past few years the dissociation of insulin in acid and neutral solution has been extensively studied. Although most of this work has pointed towards a minimum molecular weight of 12,000 from osmotic pressures[1], sedimentation[2,3] and light scattering[4] measurements, we raised the possibility of a value of 6,000 as the lower limit, from the extrapolation of sedimentation and diffusion data[5]. This value has been confirmed by surface monolayer studies[6] and by Craig and Harfenist's method[7]. Further, chemical analysis does not preclude it[8].

It has already been postulated that insulin molecules dissociate when the electric charge is increased by fixation of protons, this producing a repulsion between positively charged submolecules. It would be expected that a similar phenomenon would occur in alkaline media when submolecules carry a sufficiently high negative charge.

In the present investigation we have determined sedimentation and diffusion constants in moderately alkaline solutions of insulin, respectively by a 'Spinco' analytical ultracentrifuge and by the Lamm's scale method. (The insulin used was five times recrystallized beef insulin obtained through the courtesy of the Lilly Research Laboratories, Indianapolis.)

Fig. 1 shows the effect of *p*H on the sedimentation constant of insulin (corrected to 20° and water) at a constant concentration of 0·25 per cent protein and ionic strength 0·1. The dissociation becomes effective around *p*H 8 and reaches its maximum by *p*H 10. Titration curves indicate that at this *p*H insulin carries about 10 negative charges (calculated on the basis of 12,000 molecular weight). This is identical with the positive charge of insulin at *p*H 3 where

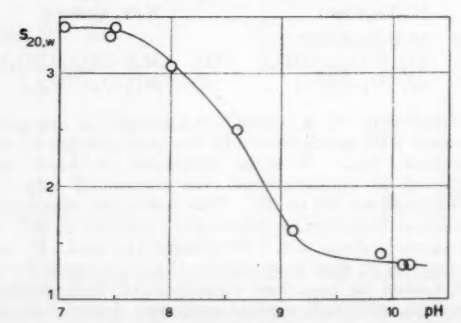

Fig. 1. Sedimentation constant of 0·25 per cent insulin in potassium chloride – glycine solutions as a function of *p*H ($\mu = 0{\cdot}1$)

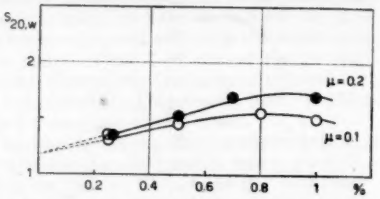

Fig. 2. Sedimentation constant of insulin in potassium chloride-glycine solutions at *p*H 10·1 as a function of protein concentration

maximum dissociation takes place also[5]. This behaviour provides good evidence that the dissociation is mainly determined by electrostatic repulsions.

Fig. 2 shows the effect of protein concentration on the sedimentation constant of insulin at *p*H 10·1 and ionic strength 0·1 and 0·2 (buffer potassium chloride – glycine). As at[5] *p*H 2·7, the sedimentation constant rises when the concentration decreases from 1 to 0·7 per cent, in accordance with the ordinary charge effect, but goes down below this point because the dissociation becomes the overwhelming factor. At both buffer concentrations the values tend to become identical and point towards a minimum around 1·2. Similar conclusions can be drawn from diffusion data (Table 1).

Table 1. Diffusion Constants of Insulin at *p*H 10·1 (Corrected to 20° and Water)

	Potassium chloride – glycine 0·1 *N*	Potassium chloride – glycine 0·2 *N*
0·15 per cent	15·7	14·1
0·30 ,,	15·0	12·5
0·45 ,,	—	11·3

The extrapolation of sedimentation and diffusion constants at zero protein concentration gives an approximate value for the insulin submolecule. It is much lower than 12,000. A combination of $s = 1{\cdot}2$, $D = 16$ and a partial specific volume of 0·72 [3] would give a molecular weight around 6,000.

The stability of insulin in these moderately alkaline solutions under the experimental conditions given is well established by Waugh's experiments on the biological activity of insulin after alkali treatment[9]. On the other hand, it can be completely and easily recrystallized after standing two days at *p*H 10 at room temperature. It also regains its normal sedimentation constant when brought back to *p*H 7.

Although in acid solution the sedimentation constant varies with the sample of insulin considered and with its age, results are much more constant at *p*H 10 (Table 2).

Table 2. Sedimentation Constants of 0·25 per cent Insulin at Ionic Strength 0·1

	*p*H 2·7	*p*H 10·1
Lot *T*-2344	1·3 to 1·6	1·3
Lot 488.098	1·8	1·3
Lot 200-1*B*-11	1·5	1·3

Similarly, in neutral or alkaline media, the dissociation is not influenced by the nature of the anions present; 0·1 *N* phosphates, chlorides or thiocyanates give identical values for s_{20} at *p*H 10·1. In acid solutions the dissociation is much influenced by the nature of the anions[6]. We related it to the binding capacity of insulin for such ions; this binding capacity does not exist in alkaline solutions.

It has been pointed out[3] that the lowering of the dielectric constant of the medium will increase the tendency of insulin to dissociate. Experiments in solutions of 20 per cent dioxane in water and 0·2 *N* potassium chloride show that the sedimentation constant of insulin both at *p*H 3·6 and 8 is markedly depressed. At *p*H 3·6 a molecular weight of 13,700 has

been deduced from sedimentation-diffusion in 20 per cent dioxane – 0·2 *N* potassium chloride; in aqueous solution it is more than 30,000. Moreover, the use of still higher concentrations of dioxane greatly increases the solubility of insulin in the isoelectric region. In 40 per cent dioxane – 0·5 *N* potassium chloride, 1 per cent insulin can be kept in solution throughout the entire *p*H scale.

A detailed account of this work will be published elsewhere. We gratefully acknowledge a research grant from Eli Lilly and Co., Indianapolis.

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Apparent Degradation of Wool by Diazomethane Solutions

THE action of diazomethane on proteins has been studied by a number of workers, who report that both O- and N-methylation occur. There is apparently no fission of the peptide chains, although it is stated[1] that the action of diazomethane on insulin causes a decrease in the cystine content. On the other hand, Kirst[2] claims that the cystine bridges in wool are unaffected by the reagent, and Herzig and Landsteiner[3] state that wool is rather more resistant to diazomethane than are other proteins. In most of this earlier work, it was specifically stated that dry proteins and dry ethereal solutions of diazomethane were used. Recently, Kuhn and Ruelius[4] have shown that diazomethane acts on aqueous solutions of peptides with formation of the corresponding betaines, while serum albumin and ovalbumin in water are slowly converted to insoluble products. We have now found that wool can be extensively degraded by ethereal diazomethane solutions, the product being almost completely soluble in water. The diazomethane, prepared from nitrosomethylurea, is added to the wool over a period of several days, together with small quantities of water. The soluble product contains no sulphur, and diffuses through 'Cellophane', while the appearance of the wool during the reaction closely resembles that of wool treated with strong alkali.

Diazomethane is known to contain methylamine as an impurity[5], and our solutions were approximately 0·01 *N* with respect to this compound. However, this weak base alone is without visible attack on wool even at high concentration. Although there is apparently very little action between diazomethane and aliphatic amines in water-free solution (cf. ref. 6), we have found that, when water is present, methylamine, but not higher aliphatic amines, is slowly methylated, producing first trimethylamine and then tetramethylammonium hydroxide, as proved by potentiometric titration and isolation of the corresponding crystalline iodides. The quaternary ammonium hydroxide is a very strong base, and the amount produced from the methylamine impurity in the diazomethane solutions, when absorbed from the ether solution by the small amount of water on the wool, is more than enough to account for the extensive digestion observed. In fact, wool is attacked even by solutions in which the diazomethane has been previously destroyed by the addition of small amounts of water. Samples of diazomethane prepared from *p*-toluenesulphonmethylamide[7] or from hydrazine and chloroform[8] also contain basic compounds and show a similar degradation of wool. The removal of the methylamine impurity proved difficult, but partial success was achieved by repeated treatment with either methyl iodide or *p*-toluenesulphonyl chloride followed by distillation. These base-free solutions show no degradative attack on wet wool.

The above results indicate that some caution might be necessary when diazomethane is used in protein studies, for example, in Chibnall's method for the determination of C-terminal residues[9]. Further, it would appear likely that some of the results observed by Head[10] during a study of the action of diazomethane on cotton and various modified cotton celluloses could be attributed to the presence in the reagent of tetramethylammonium hydroxide.

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Nitrogen Metabolism of Apple Trees

IN most plants nitrate is the form in which nitrogen is absorbed from the soil and translocated upwards from the roots. Accumulation of nitrate in upper parts of the plant may follow, nitrate reduction and formation of organic nitrogen compounds occurring in many organs. Thomas[1] showed that the nitrogen uptake of apple trees was atypical in that nitrates could normally be detected in only the finest roots, and suggested that nitrate reduction and formation of amino-acids occurred in these organs. Absence of nitrates from apple leaves has since been confirmed by many workers; but under certain conditions they have been detected[2].

During work on stock-scion nutrient interrelations in the apple, the nitrogen supply from stock to scion has been investigated. This was done by examining the level and forms of nitrogen present in tracheal sap, extracted by a simplification of the method of Bennett *et al.*[3], from one-year old shoots of mature apple trees.

The total nitrogen content of this sap, as determined by a micro-Kjeldahl method, showed considerable seasonal variation. Over the winter months the sap contained approximately 10 μgm. of nitrogen per ml. There was an increase to 20 μgm. about three weeks before blossoming, followed by a rise to a peak of 150 μgm. at flowering (about October 1). This level was maintained for about three weeks, and

Fractionation of Total Nitrogen of Tracheal Sap of Apple Trees
Results expressed as μgm. nitrogen per ml. of sap

Date	Variety	Stock	Ammonia nitrogen	Glutamine amide nitrogen	Asparagine amide nitrogen	Amino-nitrogen	Total of ammonia, amide and amino-nitrogen	Total nitrogen as determined by micro-Kjeldahl
23/10/51	Gravenstein	Northern Spy	1	11	21	88	121	121
1/11/51	Delicious	Malling XII	4	22	30	105	161	158
1/11/51	Delicious	Malling XVI	6	16	32	103	157	155
1/11/51	Gravenstein	Northern Spy	2	8	23	71	104	98
11/12/51	Delicious	Malling XII	1	10	7	36	54	54
11/12/51	Delicious	Malling XVI	1	4	20	56	81	77
11/12/51	Gravenstein	Northern Spy	1	2	12	12	27	20
24/ 3/52	Granny Smith	Malling XVI	0	1	2	13	16	17
24/ 3/52	Granny Smith	Northern Spy	0	2	2	13	17	16
24/ 3/52	Granny Smith	Malling XII	0	1	2	13	16	19

from time of petal fall there was a gradual decline until, at the end of January, the level was down to 20 μgm. and by the end of March it was back to 10 μgm.

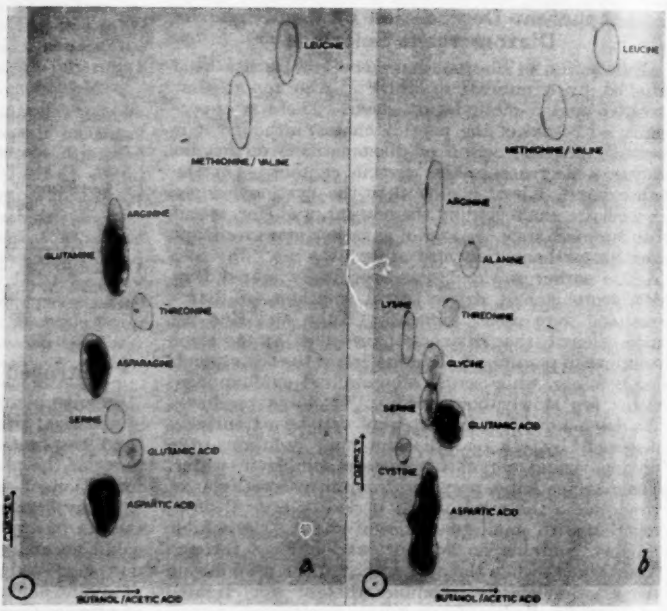
Fractionation of this nitrogen has been possible. Using phenol disulphonic acid, no nitrate could be detected. Ammonia, glutamine amide and asparagine amide were determined by vacuum distillation methods[4]. Amino-nitrogen was determined in the Van Slyke manometric apparatus, the usual correction for glutamine amide nitrogen being made. Results obtained from sap extracted at different times during the season are given in the accompanying table. It is apparent that ammonia + amide + amino-nitrogen can account for all the nitrogen present.

The individual nitrogenous compounds have been examined by paper chromatography. Tracheal sap, concentrated *in vacuo* at room temperatures, was run in phenol and butanol/acetic acid. Amino compounds were revealed by spraying with ninhydrin (0·1 per cent in *iso*propanol). The principal compounds present were always glutamine, asparagine, aspartic acid and, to a lesser extent, glutamic acid. Judged by spot intensity, these four compounds would account for up to 90 per cent of all nitrogen present. Also present in lesser amounts were serine, threonine, arginine, methionine, valine and leucine. Sometimes present in traces were alanine, tyrosine and γ-amino butyric acid. On acid hydrolysis of sap, the serine and alanine spots increased in intensity, while glycine and faint spots corresponding to lysine, cystine and sometimes cysteic acid appeared, indicating the probable presence of a peptide.

Recent work[5] has confirmed, at least with some plants, the older view that solutes absorbed by the roots pass up through the xylem vessels. The present work has shown that in the apple tree this sap contains nitrogen throughout the year, and, at times, is comparatively rich in this element. It would seem that a significant part, if not all, of the nitrogen absorbed by the root system does pass to the scion in the xylem sap.

The view that complete reduction of nitrate to amino-acids occurs in the roots is substantiated. Apart from a small amount of ammonia nitrogen, the nitrogen of amino-acids and amides accounts for all the nitrogen in the tracheal sap.

The predominance of the two dibasic amino-acids might be expected as they, together with their amides, are considered to be some of the first products formed in the synthesis of organic nitrogenous compounds. Their importance as translocatory compounds has been shown here. The presence of glutamine is of particular interest as it has not been detected[6] free in apple fruits.



Paper chromatograms showing amino-acids of tracheal sap of Granny Smith apple tree on Northern Spy stock: (*a*) sap concentrated *in vacuo* at room temperatures; (*b*) sap hydrolysed in 6*N* hydrochloric acid for 3 hr.

It is hoped to publish these results in more detail elsewhere.

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Effect of Leaf Roll Virus Infection on the Soluble Nitrogen Composition of Potato Tubers

In an attempt to verify and extend the findings of Andreae and Thompson[1] to a range of potato varieties, an apparent relationship between glutamic acid, glutamine, and virus infection has been noted. The diseased tissue used was primary infected material which had been obtained from grafts.

Microscopic examination of the tissue did not reveal the presence of necrotic lesions, which, because of the gross physiological changes involved in their formation, might conceivably be expected to produce, as secondary effects, similar biochemical differences to those found. Alcoholic extracts were prepared according to Dent, Stepka and Steward[2], taking the same weight of healthy and diseased tuber tissue (20 gm.) for each extraction. A preliminary survey of seven varieties was made by applying equal volumes of the extracts to a one-dimensional paper chromatogram (see photograph) run in phenol : water, 75 : 25 w/v. A standard set of amino-acids containing aspartic and glutamic acids, glutamine and tyrosine was run in the first, eighth and seventeenth positions. One of these compounds, glutamine, contained impurities which confuse the picture in the aspartic – glutamic acid region. In four of the seven varieties the diseased tissue appears to contain higher concentrations of glutamic acid, glutamine and asparagine. Two-dimensional chromatograms, run with *n*-butanol : acetic acid as the second solvent, showed that the amounts of alanine present were insufficient to account for the large differences appearing in the glutamine region of the single-dimensional chromatogram, but that other amino-acids, for example, serine, accounted for the apparent differences in asparagine content.

Analyses of five further varieties by two-dimensional chromatography have shown that the differences in glutamic acid and glutamine are the most consistent. Diseased tissue had two to three times the glutamine concentration of healthy tissue, while glutamic acid differences were much smaller although covering the same varietal range. Tyrosine and tryptophane, however, showed no consistent differences over the varietal range tested. A very noteworthy biochemical difference occurs in Arran Pilot tubers, in which the total amino-nitrogen in diseased tissue appears to be reduced to approximately one-third of that present in healthy tissue.

In view of the importance recently assigned to glutamic acid and the γ-glutamyl group of glutamine by Hanes, Hird and Isherwood[3], in respect of trans-peptidation reactions, these observations may have significance beyond the fact that they show promise of providing the basis for a simple and rapid diagnostic test for leaf-roll virus in potato tubers.

A fuller account of this work will be published elsewhere. I acknowledge gratefully the co-operation of Mr. C. M. Driver, who provided the material, and Miss C. M. Smart, who performed the grafts and microscopic examination of the material.

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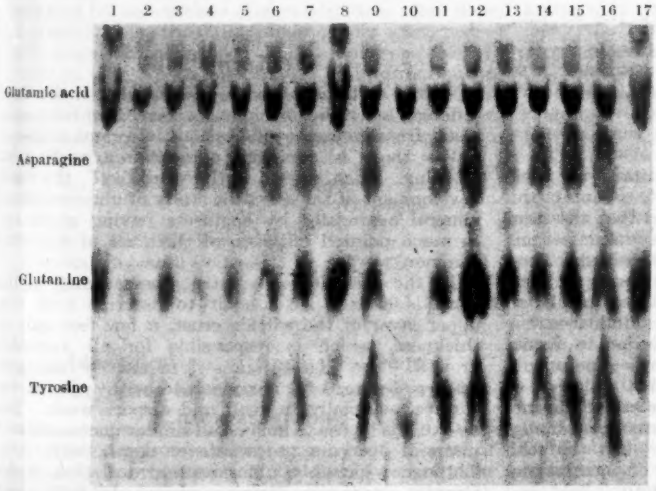

Chromatogram of soluble nitrogen fraction of healthy and diseased potato tubers. (1), (8) and (17) are standard amino-acids. The following pairs are for each variety, healthy and diseased, respectively: (2, 3) Arran Banner; (4, 5) Arran Chief; (6, 7) Arran Consul; (9, 10) Arran Pilot; (11, 12) Chippewa; (13, 14) Craig's Defiance; (15, 16) Dunbar Standard

Bacterial Degradation of Choline

During work on the production of trimethylamine by organisms isolated from the flora of the whale, it was found that some types were able to produce this substance from choline[1]. Similar observations on organisms from other sources had been made previously, the products of the degradation of choline characterized as trimethylamine and ethylene glycol, and the enzyme responsible named 'choline deaminase'[2]. No kinetic information was available, nor had the specificity of the enzyme been determined, though it had been reported that certain Enterobacteriaceæ produce trimethylamine from acetylcholine but not from betaine[3], so investigation of these questions seemed likely to prove fruitful.

The organism used was a strain of *Aerobacter aerogenes*, recently isolated from whale tissue, chosen in preference to the other choline-splitting species, which were either anaerobes or slowly growing aerobes. Its enzyme system proves to be specific for choline and acetylcholine. Ethyltrimethylammonium hydroxide and tetramethylammonium hydroxide may be attacked very slightly; but with the small quantities involved it is difficult to tell whether the trimethylamine has increased or not. It is without action on *iso*-choline, betaine, phosphorylcholine or dimethylaminoethanol.

It has been reported that trimethylamine production from choline is inhibited by glucose, and suggested that this is because the ethylene glycol simultaneously produced is no longer needed as a source of energy[3]. We have confirmed the inhibition by glucose but have found that ethylene glycol does not prevent choline breakdown. Kinetic experiments have proved to be impossibly difficult, but some observations have been made which seem worth recording. Choline is attacked by *A. aerogenes* only in the logarithmic phase of growth. When active division ceases, so also does production of trimethylamine; washed suspensions are completely inactive. The enzyme system involved is not adaptive.

We have been unable to proceed further because of difficulties in the chemical estimation. Choline cannot be estimated by the reineckate method in the presence of trimethylamine which is also precipitated, and ethylene glycol is probably metabolized. Trimethylamine can be estimated by titration with perchloric acid in a non-aqueous system or by a colour reaction with *cis*-aconitic anhydride. Both methods require the extraction of the base into an organic solvent, and we have found that direct extraction with toluene is incomplete at the higher concentrations (60–70 mgm. per cent), and that in the lower ranges (0–20 mgm. per cent) it is impossible to aspirate the trimethylamine completely into glacial acetic acid. A method of trimethylamine estimation by gas–liquid partition chromatography has been devised, but it is unsuitable for serial estimations in kinetic experiments[4].

This work was carried out as part of the programme of the Food Investigation Board of the Department of Scientific and Industrial Research.

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'Parsnip Canker'

Green and Hewlett[1], in a summary of their investigations on 'parsnip canker', stressed the importance of the disease and showed that the term 'canker' had been loosely applied to several infections which they therefore specified and classified. They concluded that only the commonest form, and the one without a known causative agent, should be so named, and they suggested that critical indoor rather than field experiments would be needed to reveal the agent. We have found from such experiments carried out over several seasons that cultures of *Streptomyces scabies* (Thaxter) Waksman and Henrici cause cankering and other stages of parsnip scabbing.

The possible link between 'canker' and the scab pathogen was indicated by cankering of parsnips and scabbing of carrots growing adjacently in a field, and led to a test of the infectivity of a culture of *S. scabies* to parsnips. The resultant cankering suggested tests of further cultures of the pathogen, which confirmed the first infection and showed that one culture, Millard and Burr's[2] strain 17, formed a common range of lesions on potatoes, beet, mangolds and radishes as well as on carrots and parsnips. Frequently one kind of lesion predominated, so that the raised scab characterized the infections on beet, mangolds, French breakfast radishes and carrots, while the surface-to-sunken sort prevailed on the potato, white icicle radish and on mature parsnips; but on parsnip seedlings the scabs were raised at first. Throughout these infections, except where union had blotted out their origins, it was clear that lesions arose in lenticels and, in all plants except the potato, the centring of lenticels in side-root rows permitted the involvement of root initials. Microtome sections confirmed this possibility, especially in carrot scabs, and they also showed, in both carrot and parsnip lesions, the series of cell changes noted by Jones[3] in potato scabs. The similarity in structure of the pitted scab of the tuber and that of parsnip cankers was close even in details, but the cankers usually formed only one protective cork barrier.

The presence of the pathogens in lesions was confirmed by re-isolating them several times and in different seasons and, in one season, a number of isolates so obtained from carrot and parsnip lesions cankered parsnips in a later season. In addition, the cultural and morphological features of the isolates agreed with those of the infecting cultures. Since the cultures used were of varied and widespread origin, being derived from potato or beet scabs formed in England, Wales and the United States, and the culture most commonly used, Millard's strain, is a well-known potato pathogen capable of scabbing several kinds of crop, these pathogens could, no doubt, cause in Nature the commonest sort of 'parsnip canker' noted by Green and Hewlett.

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The Term 'Soil'

When a term of wide use is shared between different scientific disciplines, some confusion may result from its use in publications of common interest unless there is complete agreement regarding its meaning. Such a term is the word 'soil', the rapid development of the scientific study of unconsolidated mineral aggregates by engineers having given rise to much pointed criticism of their use of this very common word.

To the agricultural scientist, the meaning of the word is clear. He uses it to describe that thin upper layer of the earth's crust, a few feet only in thickness, which is responsible for all vegetable growth. The engineer uses it in exactly the same way, since he, too, is concerned with soils at the surface, especially in road and airport work. But he extends its use to include all similar unconsolidated material overlying, to whatever depth, solid rock. Through a possibly unfortunate translation of the German expression *Erdbaumechanik*, he has coined the name 'soil mechanics' to describe his new-found scientific interest in the material for so long disdainfully regarded as mere 'earth' or often as just 'mud'.

It is this name which seems to disturb so many agricultural soil scientists and which now appears to be arousing the ire of geologists. But in my very limited geological reading, many references have been noted showing that geologists themselves have for long used the word 'soil' in exactly the same way as engineers—and no modern geological writer yet appears to have suggested a satisfactory alternative generic name for the unconsolidated part of the earth's crust. Three typical references may be cited, British, Canadian and American. In his famous "Memoir to the Map of the Strata of England" (1815), William Smith said: "The chances were thought much against my ever completing it as a map, of the greater part of our island, large enough to show the general course and width of each stratum of the soil and minerals, with a section of their proportions, dip and direction . . . ". John William Dawson, in his "Acadian Geology" (Edinburgh, 1855, p. 23), states that: "The western part of Nova Scotia presents some fine examples of marine alluvial soils". William Henry Brewer, writing on "The Deposition of Clay in Salt Water" (*Amer. J. Sci.*, 29, 1; 1885), says: "I have carried on a long series of experiments on the sedimentation of clays, and the finer portions of soils and the pulverized rocks . . . ".

Geologists, therefore, would be following a well-established tradition if they accept the use of the word 'soil' as a general description of unconsolidated material. By their use of the term 'soil profile', agricultural soil scientists show clearly that they themselves do not confine the use of the word to that thin layer with high organic content which they sometimes suggest is the 'proper' use of the word. If 'soil' is to be used to describe the 'C-horizon', how can the pedologist logically object to the use of the same word in the same way by the engineer, but used to describe the same material at depths in which the soil scientist has no interest?

Would it not therefore be generally useful to have a common understanding as to this well-accepted and well-established general use of the word 'soil'? The engineer can make his contribution by refraining from using the expression 'soil profile' to describe the record of his sub-surface exploration (as is often done at present). The three disciplines chiefly concerned—civil engineering, geology and pedology—have so much to gain by an interchange of information on soil studies that there would seem to be nothing to lose and much to gain, for the benefit of science in general, by the adoption of the very modest suggestion herein advanced.

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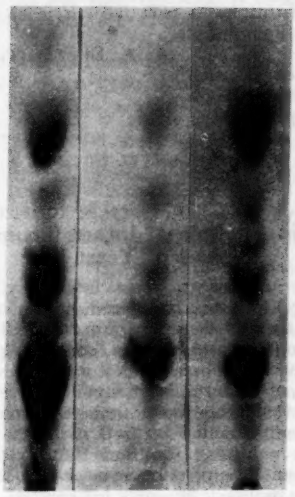
Identification of Recessive Gene Heterozygotes by means of Paper-Partition Chromatography

PAPER-PARTITION chromatography of tissues of genetically known strains of *Drosophila melanogaster* as well as those of certain plants has shown that each strain gives a constant and distinctive pattern. The chromatographic patterns of heterozygotes carrying recessive genes can be easily distinguished from those



Ninhydrin-positive materials in the chromatograms of smeared root tips of musk melon (genotypes: homozygous wild type; homozygous yellow-green; heterozygous yellow-green). Solvent: 4 *n*-butanol : 5 water : 1 glacial acetic acid

of either parental homozygous strain, even though the phenotype of the heterozygote is indistinguishable from that of the homozygous dominant. This is the case for: (*a*) the fluorescent patterns observed under ultra-violet light in the chromatograms of adult *Drosophila melanogaster* heterozygous for the following mutants: bent, eyeless[2], short-vein, spineless-aristapedia, vestigial; (*b*) the ultra-violet-fluorescent and the ninhydrin-positive patterns of root-tip smears of heterozygotes for the mutant male-sterile[2] in tomato[1]; (*c*) the ultra-violet-fluorescent and the ninhydrin-positive patterns of root-tip smears and leaf extracts of heterozygotes for the yellow-green mutant of musk melon[3] (see also chromatogram).

In all cases one-dimensional descending chromatograms were obtained on Whatman No. 1 filter paper, using the following solvents: (*a*) two parts of *n*-propanol and one part of 1 per cent ammonia; (*b*) four parts of *n*-butanol and 1 part of glacial acetic acid, made up with five parts of water. The chemical nature of the substances revealed in the patterns has not been investigated.

The remarkable constancy of the results obtained, the fact that the biochemical patterns of every tissue tested seem to fall under the control of the genotype (with a high degree of independence of feeding and other environmental conditions), and the high degree of chemical specificity evidently imparted by the genotype to the organism suggest that this technique will prove to be of value for the physiological study of gene action and for an analysis of the biochemical basis of individuality. A fuller report will be published elsewhere.

I wish to thank Dr. Charles M. Rick, of the Department of Truck Crops, University of California, Davis, California, and Dr. Thomas W. Whitaker, of the U.S.D.A. Bureau of Plant Industry, Soils and Agricultural Engineering, La Jolla, California, for the plant materials used, and members of the Department of Zoology, University of California, Berkeley, California, for help and facilities provided. The work was carried out while visiting professor at the last-

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Genetic Analysis of Intact Incomplete Asci of Yeast

Genetic analysis in yeast is usually based on tetrad analysis, that is, on microdissection and culture of the four haploid ascospores from normal four-spore asci. Incomplete asci, that is, containing only one, two or three ascospores, constitute, however, a high proportion of all asci in many crosses. We have investigated whether or not these incomplete asci could be conveniently utilized, without dissection, for genetic analysis; we find that, within limits, Mendelian analysis of one-, two- and to some extent three-spore asci is sufficiently informative to be convenient.

The strains used in the present crosses were nutritional mutants derived by ultra-violet irradiation from strains *B*15 and *C*24–13*b* of *Saccharomyces cerevisiæ* kindly supplied by Prof. B. Ephrussi. They were heterothallic, practically never producing asci in cultures derived from single ascospores. The crosses reported here were always carried out by placing two haploid cells of opposite mating type next to one another in a hanging drop, observing the formation of the zygote and isolating the diploid derived from it.

One-, two- or three-spore asci formed by these diploid strains were isolated individually and germinated intact on a nutrient agar medium. The cells from the colonies so obtained were analysed for ploidy and genotype. The genetic markers used, besides mating type, were either or both of the following monogenic differences in nutritional requirements: *AD*/*ad*, independence of, versus requirement for, adenine; *TRYP*/*tryp*, independence of, versus requirement for, tryptophane.

One-spore asci. Forty one-spore asci were isolated from a diploid α *ad* // a *AD*. Twenty-two germinated, all producing haploid strains, and eighteen of these were of a mating type. Thus, about 80 per cent of the α mating type ascospores did not produce colonies. It is not yet known whether the low viability of these ascospores is due to the mating type allele itself or to some closely linked locus. The normal formation of diploid colonies from two- and three-spore asci (see below) shows that this low viability does not manifest itself in the heterozygote or in the haploid ascospore if the latter fuses immediately with one of opposite mating type. Of the twenty-two haploid strains obtained, thirteen were *AD* and nine *ad*; that is, the two alleles segregated in ratios not significantly different from 1 : 1; there is thus no evidence of close linkage between this locus and the mating type locus. The results with one-spore asci show that the single spore represents one of the four products of meiosis.

Two-spore asci. Intact two-spore asci gave origin on germination either to colonies made up only of diploid cells all of one kind, or to colonies made up only of haploid cells which could be all of one type or of two types. Diploid colonies arise when the two spores are of opposite mating type; haploid colonies when the two spores are of the same mating type.

Table 1. Colonies Originating from Individual Two-Spore Asci

(*A*) Two spores of complementary mating types: colonies containing only diploid cells.

Cross: a *ad* // a *AD*

	Phenotypes *AD*	*ad*	Total
No. of colonies:			
Obtained	66	11	77
Expected (5 : 1 ratio)	64·2	12·8	

Cross: a *TRYP* // a *tryp*

	TRYP	*tryp*	Total
No. of colonies:			
Obtained	36	6	42
Expected (5 : 1 ratio)	35	7	

Cross: a *ad TRYP* // a *AD tryp*

	AD TRYP	*AD tryp*	*ad TRYP*	*ad tryp*	Total
No. of colonies:					
Obtained	30	3	3	1	37
Expected (25 : 5 : 5 : 1 ratio)	25·7	5·1	5·1	1	

$\chi^2 = 2{\cdot}5 \quad p = 0{\cdot}45.$

(*B*) Two spores of same mating type: colonies containing only haploid cells (only a mating type analysed).

Cross: a *ad* // a *AD*

	Phenotypes in sample of cells all *AD*	*AD* and *ad*	all *ad*	Total
No. of colonies:				
Obtained	5	10	4	19
Expected (1 : 4 : 1 ratio)	3·2	12·7	3·2	

$\chi^2 = 1{\cdot}8 \quad p = 0{\cdot}40.$

Expected ratios are based on the assumption of free recombination between all the markers used and between them and their centromeres.

Table 1 shows the classification of the colonies obtained from two-spore asci in three crosses in which only gene *AD*/*ad*, only gene *TRYP*/*tryp* or both, respectively, were segregating, besides mating type. The results show that the two ascospores of two-spore asci represent two out of the four haploid products of meiosis, and provide no evidence of linkage between the three loci involved in the crosses.

Three-spore asci. Individual colonies from intact three-spore asci are expected to contain two kinds of cells: diploid, resulting from fusion of two ascospores of complementary mating type, and haploid, resulting from the odd ascospore. In fact, about half the colonies obtained from three-spore asci were found to contain only diploid cells, presumably because in the other half the odd spore, which should have given origin to haploid cells, was of α mating type and failed to germinate (see Table 2). The diploid cells from each ascus have been invariably found to be of one type, confirming that usually two ascospores of complementary mating type fuse on germination without first dividing. Whether this conclusion is of general validity or is the consequence of the poor viability of the α mating type cells in the present crosses remains to be seen. The results show that the three

Table 2. Colonies Arising from Individual Three-Spore Asci. Cross α *ad* // a *AD*

Phenotypes of Haploid cells	Diploid cells	No. of colonies
a *AD*	*AD*	5
	aa	0
a *ad*	*AD*	4
	ad	0
α *AD*	*AD*	0
	ad	0
α *ad*	*AD*	0
	ad	0
Not present	*AD*	5
	ad	2
	Total	16

		Phenotypes *AD*	*ad*	Total
Diploids:	Obtained	14	2	16
	Expected (5 : 1 ratio)	13·3	2·7	
Haploids:	Obtained	5	4	9
	Expected (1 : 1 ratio)	4·5	4·5	

spores of three-spore asci represent three out of the four products of meiosis.

The present work indicates that Mendelian analysis, as distinct from tetrad analysis, is possible in yeast, and in certain cases it is labour saving.

E. A. Bevan*

Department of Genetics,
University of Glasgow. Oct. 16.

* Present address: Department of Zoology, Dartmouth College, Hanover, N.H., U.S.A.

Absorption of Water by the Egg of the Garden Chafer, *Phyllopertha horticola* L.

Many insect eggs absorb water from the environment[1]. Absorption usually occurs over a limited period during the early stages of development. The mechanism of the control of absorption is being studied in the egg of the garden chafer.

In Nature, the female chafer lays her eggs in June; about the middle of July the larvæ hatch and begin to feed on the grass roots. For 3½ months the grubs feed and grow, moulting twice. The full-grown third instar larva goes into hibernation about the end of October, resting in a small cavity 3–5 in. deep in the soil. Pupation occurs towards the end of April and the beetle emerges from the pupal skin at the end of May. After staying in the hibernation cavity for a few more days, to complete development, the adult emerges from the soil to mate. The female returns to the soil to lay her eggs.

When laid, the egg is usually a white prolate spheroid, weight 1 mgm., length 1·5 mm. and diameter 1 mm. approximately. On the third day after laying, at 20° C. and 100 per cent relative humidity, the egg begins to absorb water and by the eighth day reaches a weight of 3 mgm., measuring about 2 mm. × 1·5 mm. The weight then remains at that level until the larva hatches on the twentieth day.

The absorption period, from the third to the eighth day, is accompanied by changes in the rate of loss of water of the egg when desiccated. On the first day after laying, the egg loses water (in 0 per cent relative humidity) at the rate of 1 mgm./sq.cm./hr. On the second day the rate of water loss increases, rising to a maximum, on the fifth day, of about 20 mgm./sq.cm./hr. Thereafter the rate falls and by the tenth day has dropped to 0·7 mgm./sq.cm./hr. It is well known that insect-covering membranes show asymmetry in that water passes across them more rapidly in one direction than the other[2]. Thus the rate at which the egg loses water tells us little about the rate at which water is able to pass in through the egg shell. However, changes in rate of loss of water will reflect changes in permeability to inward flow of water.

Changes have also been observed in the thickness of the egg shell. The shell of the new-laid egg is about 8 μ thick. By the end of the absorption period the shell is nearly 15 μ thick. This increase may perhaps be a swelling of the shell material itself, but seems more likely to be due to the addition of material by the embryo.

These observations suggest a possible mechanism by which the uptake of water is regulated: the egg is laid down having a relatively waterproof layer in the shell. This is broken down by the developing embryo; the egg can then absorb water apparently passively due to its high osmotic pressure. When the egg has swollen to its full size, the shell is re-waterproofed by the embryo and absorption stops.

Roger Laughlin

Agriculture Department, King's College,
Newcastle upon Tyne. Aug. 28.

[1] Buxton, P. A., *Biol. Rev.*, **7**, 275 (1932). Matthee, J. J., Union of S. Africa, Sci. Bull., No. 316 (1951).
[2] Hurst, H., Discuss. Farad. Soc., No. 3, 193 (1948).

Nocturnal Mating in *Tæniorhynchus* (*Mansonioides*) *uniformis* (Theobald)

Mating in *Tæniorhynchus* (*Mansonioides*) *uniformis* (Theobald) was observed taking place on the night of December 7, 1951, between 18.30 hr. and 22.30 hr., while all-night trapping of mosquitoes was in progress at a cattle-shed in a village on the outskirts of Colombo. On this night it was quite dark by 18.15 hr., but for the light of the moon which was two days after the first quarter. Mating activity took place in three stages. In the first and third stages, which lasted from 18.30 hr. until 19.30 hr. and during 20.30 hr.–22.30 hr. respectively, mating was in active progress. In between these two periods of considerable activity there occurred a lull from 19.30 hr. until 20.30 hr., during which far fewer pairs of mosquitoes were observed copulating, and relatively few males were found coming into the trap. But at no time during this period of four hours was mating not in progress, and 292 females and 195 males were caught; these numbers represented only a small proportion of *T. uniformis* in the trap, for owing to great activity among the mosquitoes, catching was seriously interfered with. No mating occurred after 22.30 hr.

Three types of mating behaviour were observed occurring simultaneously. In the first, males were copulating with blood-fed females which were resting on the trap-net. In the second, males and females were seen flying *in copulo*, the females being in the lead, while in the third type males were seen to copulate with females in flight.

Although observations have been carried out at this site on more than a hundred occasions, no swarming of males of *T. uniformis* has ever been encountered, while mating only occurred on this particular night. These observations on *T. uniformis* appear to be the first record of nocturnal mating of a mosquito in Nature. It took place over a period of four hours and in the absence of any swarming by the males.

A more complete account will be published elsewhere.

S. H. Jayewickreme

Medical Research Institute,
Colombo 8. Sept. 17.

Absence of the Sickle Cell Trait in the Bushmen of South-West Africa

During the course of a general survey of the black races of southern Africa for the sickle cell trait—the results of which will be published elsewhere—an opportunity arose of examining blood specimens from 118 Bushmen. Fifty-eight specimens were obtained from Barakwenga or River Bushmen living in the western section of the Caprive Zipfel in the north-east of South-West Africa. The remainder were from south of the Okavango River near the western border of Bechuanaland.

Whole blood specimens were collected in sterile 'Venules' or sterile corked specimen tubes and sent to Johannesburg by air for examination, where they arrived about a week after collection. Sixty samples collected in specimen tubes arrived showing a moderate degree of hæmolysis, whereas the specimens collected in the 'Venules' arrived in excellent condition. The bloods were tested for the sickle cell trait using the sodium hydrosulphite method of Williams and Mackey[1] or the sodium meta-bisulphite method of Daland and Castle[2]. Fifteen specimens were tested by both these methods and by the sealed coverslip method read after 24 hr. Fifty-eight specimens were examined in parallel with specimens of known sickle cells in order to assess the efficiency of the reducing agent used. These controls invariably showed marked sickling within 30 min. The specimens of Bushmen bloods were examined 30, 60 and 90 min. after adding the reducing agent. All of 118 specimens examined were found to be negative.

The age- and sex-distribution of fifty-eight specimens is shown in the table. The youngest individual tested was a male aged five years—the oldest was a male aged fifty-six. The remaining sixty specimens were random samples obtained from the population of the area. At the same time, 119 specimens of blood from members of the Mpukushu tribe living in the Western Caprive Zipfel were also examined with similar negative results.

Age in years	Males	Females	Total
0–5	1	1	2
6–10	8	5	13
11–15	2	5	7
16–20	4	2	6
21–25	2	5	7
26–30	3	8	11
31–35	–	5	5
36–40	3	1	4
41–45	1	1	2
46–50	–	–	–
51–55	–	–	–
56–60	1	–	1
Total	25	33	58

The ethnological importance of the absence of the sickle cell trait in the Bushman, contrasting with the high incidence of the trait in the black races of Central, East and West Africa, and especially in the Pygmies of Central Africa[3], will be discussed elsewhere.

I wish to thank Dr. Kuschke, regional health officer of the Okavango area, who collected these specimens.

S. B. Griffiths
South African Institute for Medical Research,
Johannesburg.
Aug. 12.

[1] Williams, A. W., and Mackey, J. P., *J. Clin. Path.*, **3**, 141 (1949).
[2] Daland, G. A., and Castle, W. B., *J. Lab. and Clin. Med.*, **33**, 1082 (1948).
[3] van den Berghe, L., and Janssen, P., *Ann. Soc. Belge de Med. Trop.*, **30**, 1553 (1950).

Tainting of Tobacco by a Dichloropropene–Dichloropropane Soil Fumigant

I wish to refer to the letter under the above title from Dr. C. J. Shepherd in *Nature* of December 20, p. 1073. The work mentioned was carried out while Dr. Shepherd was employed by the Tobacco Pest Control Research Scheme here and was submitted to the Executive Committee, of which I was chairman. After very full consideration it was decided that the results of this particular investigation should not be published, as it was of a preliminary nature and carried out on a commercial crop on a farm. In other words, no control was possible and it is even conceivable that the tainting resulted from incorrect use of the fumigant. The Tobacco Pest Control Research Scheme has ceased operations and its activities have been handed over to the Tobacco Research Board, which has well-designed experiments in progress to check this using both dichloropropene-dichloropropane and ethylene dibromide.

I appreciate that Dr. Shepherd's communication is in the nature of a preliminary notification of work in progress, and this could have been equally well achieved by omitting the first paragraph. I am concerned, however, lest a completely wrong impression be given regarding the quality of Rhodesian tobacco. The estimate of five per cent of the crop being affected is a very wild guess, and the considered opinion of authorities here is that the little tainting noticed was due either to failure to follow instructions for the use of the fumigant, or to the abnormal wet weather experienced at time of planting.

R. McChlery
(Director of Research
and Specialist Services)

Division of Agriculture and Lands,
P.O. Box 25 Causeway,
Southern Rhodesia.
Jan. 26.

A Riss-Würm Interglacial Deposit at Ipswich

During recent months, excavations for new sewage works near Ipswich have exposed lacustrine deposits, between the Upper Chalky Boulder Clay (Gipping) and contorted beds, which there is every reason to believe are referable to the Würm glaciation.

The deposits, consisting of silt, calcareous clay and peaty detrital mud, are cut into and are overlaid with mixed materials which elsewhere in the district can be demonstrated to be equivalent to a 'till' with derived masses of Gipping C.B.C. included. There is a very rich molluscan fauna with which are associated bones and teeth of field mice, voles, frogs or toads, fishes and the European freshwater tortoise (*Emys orbicularis* L.). Bison and *Elephas primigenius* are indicated by fragmentary remains; but the use of mechanical excavators results in breaking up the bones of the larger fauna, few of which are found. A split deer radius bearing cuts suggests nearby human occupation.

It is evident these deposits are contemporary with the well-known Stoke Tunnel Beds examined by the late Miss N. F. Layard, where mammoth and *Emys* were also discovered together with *Bos primigenius*, *Cervus elaphus*, *Equus caballus*, and lion, bear, wolf, fox, etc.

The molluscs and pollen grains are being studied. A number of coleopteran fragments are available for examination.

Harold E. P. Spencer

Museum Buildings,
High Street,
Ipswich.
March 9.

FORTHCOMING EVENTS

Saturday, March 28

ASSOCIATION OF CLINICAL BIOCHEMISTS (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2.30 p.m. —Inaugural Meeting.

Monday, March 30

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "Use and Abuse of Research" (to be opened by Dr. S. Whitehead).

SOCIETY OF ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. R. Weck: "Structural Failure and What we Learn from It".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.15 p.m.—Dr. E. Wyss-Dunant: "Swiss Everest Expedition, 1952" (Dickson Asia Lecture). (Admission by special ticket only.)

Tuesday, March 31

SOCIETY OF INSTRUMENT TECHNOLOGY (joint meeting with the CONTROL SECTION, at Manson House, 26 Portland Place, London, W.1), at 6.30 p.m.—Dr. G. L. d'Ombrain: "The Presentation of Control Theory and the Training of Control Engineers".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. W. E. Gray: "Experimental Work on Boundary Layer Flow".

Wednesday, April 1

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Discussion on "The Determination of Small Amounts of Lead in Foods and Biological Materials".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ANALYST, Grade IVb (Int.), for duties concerned mainly with analysis of agricultural products in advisory and experimental work—The Secretary, Edinburgh and East of Scotland College of Agriculture, 13 George Street, Edinburgh (April 4).

EDUCATIONAL PSYCHOLOGIST (with a degree in psychology)—The County Medical Officer, County Hall, Kingston-upon-Thames, Surrey (April 4).

ASSISTANT LECTURERS IN THE DEPARTMENTS OF BIOLOGY, CHEMISTRY, PHYSICS—The Warden and Secretary, Royal Free Hospital School of Medicine, Hunter Street, London, W.C.1 (April 10).

SOIL CHEMIST (with a degree in science, preferably honours, and an interest in chemistry relating to soils or in physical chemistry) at Auchincruive—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (April 10).

ASSISTANT LECTURER IN ANIMAL PHYSIOLOGY—The Secretary and Registrar, The University, Southampton (April 11).

STEROID CHEMIST TO THE ENDOCRINE LABORATORY at the Chelsea Hospital for Women—The Secretary, Queen Charlotte's Hospital, 339 Goldhawk Road, London, W.6 (April 11).

ASSISTANT EXPERIMENTAL OFFICER for laboratory and field work in plant pathological research on diseases of the potato—The Secretary, Agricultural Research Council, 15 Regent Street, London, S.W.1 (April 15).

LECTURER IN INORGANIC CHEMISTRY (with experience and interest in research in some branch of inorganic chemistry)—The Registrar, King's College, Newcastle-upon-Tyne (April 15).

ENGINEER or PHYSICIST IN THE MECHANICAL ENGINEERING DEPARTMENT, Royal Aircraft Establishment, Farnborough, to carry out analytical and experimental work on problems in connexion with cooling of high-speed aircraft—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.67/53A (April 16).

INSPECTOR (Salmon and Freshwater Fisheries) IN THE MINISTRY OF AGRICULTURE AND FISHERIES (candidates must hold at least a second-class honours degree in natural science with zoology or biology as a principal subject, or in some other natural science and have specialized subsequently in zoology or biology)—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.191/53 (April 16).

SENIOR GEOLOGISTS in the Atomic Energy Division of the Geological Survey—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.169/53 (April 16).

ASSISTANT LECTURER IN THE DEPARTMENT OF PHYSICS—The Registrar, University College, Aberystwyth (April 18).

ASSISTANT ZOOLOGIST (with an honours degree in zoology and a knowledge of botany) for work in connexion with investigations on potato root eelworm—The Secretary, School of Agriculture, Cambridge (April 20).

LECTURERS or ASSISTANT LECTURERS IN AGRICULTURE, AGRICULTURAL ENGINEERING and AGRICULTURAL CHEMISTRY, at the University College of Khartoum, Sudan—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (April 20).

ASSISTANT FUEL ENGINEER (with a good B.Sc., mechanical engineering or fuel technology, or equivalent qualification) in the Experimental Mobile Testing Unit of Production Department—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/609 (April 22).

ASSISTANT LECTURER or LECTURER IN THE DEPARTMENT OF GEOGRAPHY—The Registrar, University College of North Staffordshire, Keele, Staffs. (April 22).

CHAIR OF MORBID ANATOMY at Charing Cross Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 23).

ASSISTANT LECTURER IN APPLIED MATHEMATICS—The Registrar, University College, Hull (April 24).

READERSHIP IN AGRICULTURAL ECONOMICS at Wye College—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 24).

SCIENTIST, Grade II (with a good honours degree, or equivalent, and at least three years postgraduate research experience in telecommunications, automatic control or electromagnetic theory) at the Central Research Establishment II, Worton Road, Isleworth—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/608 (April 25).

ASSISTANT LECTURER IN GEOLOGY (with special qualifications in petrology)—The Registrar, The University, Manchester 13 (April 27).

ASSISTANT LECTURER or LECTURER IN PHYSICS—The Registrar, The University, Leeds 2 (April 27).

ASSISTANT (Scientific) for histological and general biological work—The Director, The Laboratory, Citadel Hill, Plymouth (April 30).

LECTURER IN MECHANICAL ENGINEERING (special experience in heat engines and/or fluid mechanics an advantage) at the University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (April 30).

ASSISTANT LECTURER or LECTURER IN CHEMISTRY (with special interest in inorganic or analytical chemistry), an ASSISTANT LECTURER IN CHEMISTRY (with special interest in physical chemistry), and an ASSISTANT LECTURER IN CHEMISTRY (with special interest in organic chemistry)—The Registrar, The University, Sheffield (May 1).

ASSISTANT LECTURER IN CHEMISTRY—The Registrar, The University, Manchester 13 (May 6).

LECTURER or ASSISTANT LECTURER IN PHYSICAL OR ORGANIC CHEMISTRY—The Secretary and Registrar, The University, Southampton (May 9).

RESEARCH OFFICERS (Chemical Engineers, with B.Sc. honours or B.Sc. (Eng.) degree in chemical engineering or equivalent qualification) for process development work in the National Chemical Research Laboratory, Pretoria—The Secretary-Treasurer, South African Council for Scientific and Industrial Research, P.O. Box 395, Pretoria, South Africa (May 11).

LECTURER IN BOTANY at the University of Melbourne—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (May 15).

LECTURER IN THEORETICAL PHYSICS—The Registrar, The University, Liverpool (May 15).

SENIOR and JUNIOR FELLOWSHIPS—The Director, Atomic Energy Research Establishment, Harwell, Didcot, Berks (May 18).

LECTURER (with a university degree in mining and a first-class colliery manager's certificate) IN MINING—The Registrar, The University, Leeds 2 (May 29).

RESEARCH ASSISTANTS for work (*a*) on the physical and chemical aspects of selective flotation (candidates should hold a good honours degree in physics or physical chemistry), and (*b*) on mining research problems, either in the Department's laboratories or, where necessary, in the mines (candidates should hold a good honours degree in mining or in civil or mechanical engineering)—The Registrar, The University, Leeds 2 (May 29).

ASSISTANT (with an honours degree in electrical engineering, and some research experience desirable) IN THE DEPARTMENT OF ENGINEERING—The Secretary, The University, Edinburgh (June 1).

FOULERTON RESEARCH FELLOWSHIP IN MEDICAL SCIENCE—The Assistant Secretary, Royal Society, Burlington House, Piccadilly, London, W.1 (June 1).

BOTANIST or PLANT PHYSIOLOGIST (with honours degree) to assist in the investigation of the uptake of nuclear fission products by marine algæ—The Secretary, Institute of Seaweed Research, Inveresk, Midlothian.

DESIGN ENGINEERS to undertake duties of project engineers, including the design and layout of special plant and equipment—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting 440.

ELECTRICAL ENGINEERING ADVISER in Ceylon under the Colombo Plan, to advise on the planning, construction and operation of hydro-electric and thermal power stations—The Ministry of Labour and National Service, Almack House, 26 King Street, London, S.W.1, quoting A.12/CE.300/52.

EXECUTIVE ENGINEER, Public Works, Electricity and Land Survey Department, Zanzibar—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.112/10/01.

EXPERIMENTAL OFFICER IN THE RADIO RESEARCH ORGANIZATION, Teddington, for abstracting scientific and technical articles on radio research and development—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.268/52A.

GRADUATE IN CHEMISTRY OR PHYSICS to undertake abstracting of technical literature, preparation of literature surveys and other technical intelligence work—The Secretary, Research Association of British Rubber Manufacturers, 105 Lansdowne Road, Croydon.

LECTURER or ASSISTANT LECTURER IN THE DEPARTMENT OF CIVIL ENGINEERING—The Secretary and Registrar, The University, Southampton.

MECHANICAL ENGINEER IN THE PUBLIC WORKS DEPARTMENT, Malaya—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.112/60/08.

ROBERT CORMACK FELLOWSHIPS IN ASTRONOMY—The General Secretary, Royal Society of Edinburgh, 22 George Street, Edinburgh 2.

SCIENTIFIC OFFICER (non-medical) IN THE DEPARTMENT OF HÆMATOLOGY—The Superintendent, Royal Hospital, West Street, Sheffield 1.

SENIOR and JUNIOR positions in the DEPARTMENTS OF ANATOMY, PHARMACOLOGY and PHYSIOLOGY, HEBREW UNIVERSITY—Prof. Samson-Wright, Middlesex Hospital Medical School, London, W.1.

STATISTICIAN IN THE DEPARTMENT OF AGRICULTURE, Kenya, to advise on the design of field and other experiments conducted by the Department, including sampling investigations and surveys, and to assist in the statistical analysis of results—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.63/7/03.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Report from the Select Committee on Nationalised Industries, together with the Proceedings of the Committee, Minutes of Evidence and Appendices. Pp. xxvi+140. (London: H.M. Stationery Office, 1952.) 6*s*. 6*d*. net. [1612

Volta River Aluminium Scheme. (Cmd. 8702.) Pp. ii+22. (London: H.M. Stationery Office, 1952.) 9*d*. net. [1612

National Parks and Access to the Countryside Act, 1949. Third Report of the National Parks Commission for the Year ending 30th September 1952. Pp. iv+30. (London: H.M. Stationery Office, 1952.) 2*s*. 6*d*. net. [1612

Air Ministry: Meteorological Office. Meteorological Reports No. 11: Dustatorms of the Anglo-Egyptian Sudan. By M. H. Freeman. (M.O. 535f.) Pp. ii+22+4 plates. (London: H.M. Stationery Office, 1952.) 1*s*. 6*d*. net. [1612

Planning Maps. Explanatory Texts, No. 5: Vegetation—the Grasslands of England and Wales. Pp. ii+10. (Chessington: Ordnance Survey Office, 1952.) 9*d*. net. [1612

Ministry of Food. Domestic Food Consumption and Expenditure, 1950, with a Supplement on Food Expenditure by Urban Working-Class Households, 1940–1949; Annual Report of the National Food Survey Committee. Pp. 132. (London: H.M. Stationery Office, 1952.) 4*s*. 6*d*. net. [1612

Northampton Polytechnic. Report of the Governing Body for the Year 1951–52. Pp. 14. (London: Northampton Polytechnic, 1952.) [1812

Department of Scientific and Industrial Research. Report of the Road Research Board with the Report of the Director of Road Research for the Year 1951. Pp. iv+86+8 plates. (London: H.M. Stationery Office, 1952.) 3*s*. 6*d*. net. [1812

Ministry of Fuel and Power: Safety in Mines Research Establishment. Research Report No. 49: Dispersion of Dust Deposits by Blasts of Air, Part 2. By J. G. Dawes. Pp. 44. (Sheffield: Safety in Mines Research Establishment, 1952.) 2*s*. 9*d*. [1812

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 896, Vol. 245: The Disturbance due to a Line Source in a Semi-Finite Elastic Medium with a Single Surface Layer. By Margery Newlands. Pp. 213–308. 22*s*. No. 897, Vol. 245: A Negative Experiment relating to Magnetism and the Earth's Rotation. By P. M. S. Blackett. Pp. 309–370. 14*s*. (London: Cambridge University Press, 1952.) [11

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 642, Vol. 237: The Morphology of *Stauropteris burntislandica* P. Bertrand and its Megasporangium *Bensonites fusiformis* R. Scott. By K. R. Surange. Pp. 73–91. (London: Cambridge University Press, 1952.) 9*s*. 6*d*. [11

Scottish Marine Biological Association. Annual Report, 1951–52. Pp. 40. (Millport: Marine Station, 1952.) [11

Bulletin of the British Museum (Natural History). Zoology, Vol. 1, No. 10: Mammals collected by Mr. Shaw Mayer in New Guinea, 1932–1949. By Eleanor M. O. Laurie. Pp. 269–318. (London: British Museum (Natural History), 1952.) 15*s*. [11

Ministry of Works. Post-War Building Studies No. 29: Fire Grading of Buildings. Part 2: Fire Fighting Equipment; Part 3: Personal Safety; Part 4: Chimneys and Flues. By a Joint Committee of the Building Research Board of the Department of Scientific and Industrial Research and of the Fire Offices' Committee. Pp. 131. (London: H.M. Stationery Office, 1952.) 4*s*. 6*d*. net. [11

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